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INDEPENDENT REVIEW OF THE DEVELOPMENT RISKS ASSOCIATED WITH THE COMANCHE ARMED RECONNAISSANCE HELICOPTER

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Director, Tactical Warfare Programs

IDA

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PREFACE

This paper reports the results of an independent assessment of the risks associated with the Army's proposed plan to streamline development of the new RAH-66 COMANCHE armed reconnaissance helicopter. The assessment was conducted by a panel of outside experts assisted by senior research staff from the Institute for Defense Analyses. Mr. Pete Adolph served as Chairman of the Panel. Dr. L. Dean Simmons was the IDA Project Leader for the task. The other outside members of the panel included Mr. Dick Ballard, Professor Alfred Gessow, Mr. Lou Herrick, Mr. Matt McGuire, and Mr. Nic Torelli. Other IDA participants included Mr. Lucien Biberman, Mr. Bill Brykczynski, and Dr. David Sparrow. The review was carried out between June 28, 1994 when the panel first convened and August 29, 1994 when the results were presented to the cognizant officials within the Office of the Secretary of Defense.

The assessment was conducted in response to a request from the Director Tactical Warfare Programs, Office of the Under Secretary of Defense Acquisition and Technology.[1] Mr. Andrus Viilu, Director of Land Warfare Programs, and Mr. Guntis Sraders, also of Land Warfare Programs, served as TWP project managers for the task; their efforts to assist us were considerable and are hereby gratefully acknowledged. The authors also acknowledge the insightful and constructive guidance provided by the IDA Review Committee -- Mr. Thomas Christie, Dr. Lemmuel Hill, and Dr. J. Richard Nelson -- and its chairman, Dr. David Randall. Additional review comments were provided by Mr. Philip Major, IDA Vice President-Programs. In addition, the authors acknowledge the assistance provided by the many industry and Government personnel with whom we interacted during the course of our review. Their open and in-depth responses to our inquiries added measurably to our understanding and appreciation of the risks associated with COMANCHE development. Finally, the authors acknowledge the superb administrative and secretarial support provided by Mrs. Sharon Tilman at IDA.

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1 *Independent Risk Assessment for the RAH-66 COMANCHE Program*, Contract DASW01-94-C-0054, Task T-F1-1310.

This briefing describes the results on an independent assessment of the risks associated with the Army's proposed plan to streamline development of the new RAH-66 COMANCHE armed reconnaissance helicopter. The assessment was conducted by a panel of outside experts assisted by senior research staff from the Institute for Defense Analyses. Mr. Pete Adolph served as Chairman of the panel. Dr. L. Dean Simmons was the IDA Project Leader for the task. The assessment was conducted between June 28, 1994 when the panel first convened and August 29, 1994 when the results were presented to the cognizant officials within the Office of the Secretary of Defense.

COMANCHE RISK REVIEW

PETE ADOLPH, *PANEL CHAIRMAN*
L. DEAN SIMMONS, *IDA PROJECT LEADER*

AUGUST 1994

This and the following chart place the independent risk assessment in context. As indicated here, the Army is developing the COMANCHE as a replacement for its existing fleet of light attack and scout helicopters, specifically the AH-1 COBRAs, the OH-58A and C model KIOWAs, and the OH-6 CAYUSEs. Present plans call for deployment of the COMANCHE to begin in FY 2003, with Initial Operational Capability (IOC) planned for early FY 2004. Total procurement is eventually expected to reach 1,292 helicopters, with production peaking at 120 aircraft per year. The Army has established an average fly-away cost goal of $8.1 million (measured in FY 1988 dollars) per COMANCHE. In current FY 1995 dollars, the cost goal amounts to roughly $10 million per helicopter.

The COMANCHE incorporates a significant number of advanced design features. The air vehicle includes an all composite airframe, a 5-bladed bearingless main rotor, a fan-in-fin design tail rotor, and a fly-by-wire flight control system. The COMANCHE will be powered by the upgraded version of the T-800 turbine engine, which was developed separately and is provided to the COMANCHE Joint Program as Government Furnished Equipment (GFE). A weight empty goal of 7,800 pounds has been established for the helicopter.

In addition to the advanced air vehicle features of the design, the COMANCHE will be outfitted with an integrated suite of sophisticated avionics, including advanced sensors, communications and navigation systems, and aircraft survivability equipment. All of these components will be controlled through advanced displays similar to those in state-of-the-art tactical fixed-wing aircraft. Among the sensors to be carried by COMANCHE are a night vision pilotage system (NVPS) and an electro-optical target acquisition system both built around advanced Focal Plane Array (FPA) forward-looking infrared (FLIR) systems. Other target acquisition components include a laser range finder/designator, the LONGBOW target acquisition radar, and an image intensifying television (I2TV) system.

BACKGROUND

- ARMY IS DEVELOPING COMANCHE AS REPLACEMENT FOR EXISTING FLEET OF AH-1, OH-58C, AND OH-6 LIGHT ATTACK AND SCOUT HELICOPTERS
  - Planned Buy of 1,292 with Deployment Beginning in FY 2003
  - Per Aircraft Fly-Away Cost Goal of $8.1M in FY 88 Dollars

- PRINCIPAL COMANCHE CHARACTERISTICS
  - Air Vehicle: All Composite Airframe, Bearingless Main Rotor, Fan-in-Fin Tail Rotor, Fly-by-Wire Flight Control System, T-800 Engine as GFE, Weight Empty 7,800 lbs
  - Integrated Avionics: Sensors, Comm/Nav, Aircraft Survivability Equipment
  - Sensor Suite: NVPS, EO TAS, Laser RF/D, LONGBOW Radar, I2TV (prov)
  - Weapons: HELLFIRE, Air-to-Air STINGER, 20-mm Turreted Gun, Rockets, Fire & Forget HELLFIRE
  - Survivability: Reduced RCS, Reduced IR Signature, Reduced Acoustic Signature, Aircraft Survivability Equipment, NBC Protection

As part of its armament suite, the COMANCHE will carry the Army's existing laser-guided HELLFIRE missile, the air-to-air STINGER missile, rockets, and a new turreted 20-mm gun system. Once LONGBOW is fitted onto COMANCHE, the helicopter will be able to use the radar-guided Fire-and-Forget HELLFIRE missile.

To enhance its survivability, the COMANCHE has been designed with reduced radar, infrared, and acoustic signatures. Advanced techniques have been employed to lower the helicopter's radar cross section (RCS), and its infrared (IR) and acoustic signatures. In addition, the COMANCHE is outfitted with various aircraft survivability equipment (ASE) to help protect itself against an adversary's air defenses. The COMANCHE also is protected against nuclear, biological, and chemical (NBC) threats through provision of an internal overpressure system.

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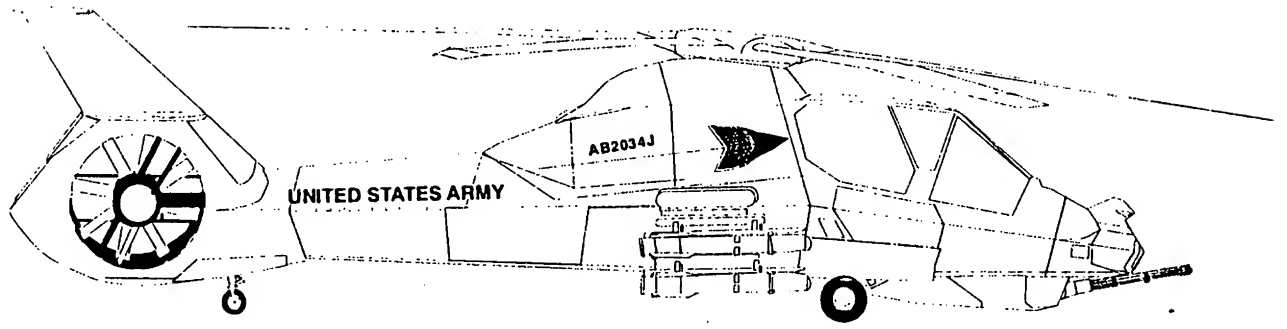
The COMANCHE is being developed jointly by Boeing Helicopters Division and Sikorsky Aircraft. Boeing is primarily responsible for the helicopter's mission equipment package (MEP) and is being assisted by the various subcontractors shown on this chart. Sikorsky and its subcontractors have primary responsibility for the airframe.

RAH-66 COMANCHE



BOEING

MARTIN MARIETTA
- Targeting and Night Vision Piloting System
- LONGBOW

WESTINGHOUSE
- Mission Processor
- Targeting Software
- Survivability Systems
- LONGBOW

HARRIS
- Digital Map
- Controls and Displays

CAE LINK
- Integrated Training System

TRW
- Communications
- Navigation
- Survivability Systems

MOOG
- Actuators

LEAR ASTRONAUTICS
- Flight Control Computer
- Side-Arm Controller

SIKORSKY

HAMILTON STANDARD
- Environmental Control System
- Air Vehicle Interface Control System

WILLIAMS INTERNATIONAL
- Secondary Power Unit

KAISER ELECTRONICS
- Helmet Integrated Display and Sighting System

SUNDTRAND
- Electrical System & Controls

MARTIN MARIETTA
- 20-mm Turreted Gatling Gun

Over the last several years, the funding profile and development schedule for the COMANCHE have been modified frequently as budgetary pressures have forced the Army to adjust the level of resources available for the program. COMANCHE development is currently in the Demonstration/Validation (DEM/VAL) phase, with the Engineering and Manufacturing Development (EMD) phase scheduled to begin in FY 1998. Early in 1994 the Army determined that it would be difficult to complete the planned EMD phase with the currently projected funding profile. As an alternative, the Army proposed a "streamlined" development approach that combined the remaining DEM/VAL development activities with EMD into a single development phase. In the Army's view, this approach would reduce program costs by eliminating many of the redundant development activities associated with the DEM/VAL-EMD approach and allow a smoother transition to production. To further reduce program costs, the COMANCHE Program Office requested relief from a significant number of Department of the Army, OSD, and legislative regulatory requirements. With these changes, the Program Office argued that COMANCHE development could be fit within the currently planned funding profile.

The Army's "streamlined" COMANCHE development plan was presented to the OSD Conventional Systems Committee (CSC) in May 1994 to determine if a review by the Defense Acquisition Board (DAB) would be required. During the CSC review, the committee expressed concern that this approach could significantly increase program risk. It was proposed that an external review group be established to review the Army's "streamlined" program.

BACKGROUND (Cont'd.)

- IN MAY 1994, ARMY PROPOSED "STREAMLINED" DEVELOPMENT AS MEANS TO FIT COMANCHE PROGRAM WITHIN PROJECTED BUDGET
  - Combines DEM/VAL and EMD Into Single Development Phase
  - Seeks Relief From Significant Number of Regulatory Requirements
  - Stretches Development
- OSD CONCERNED THAT STREAMLINED PROGRAM MIGHT SUBSTANTIALLY INCREASE RISK
  - Requested Independent Review

Following the CSC meeting, the Principal Deputy Under Secretary of Defense for Acquisition and Technology directed that an independent review group be established to assess the developmental risks imposed by the Army's proposed approach to "streamlining" COMANCHE development. This paper reports that group's assessment and its recommendations to the Department of Defense.

OBJECTIVE

- PROVIDE AN INDEPENDENT ASSESSMENT OF THE DEVELOPMENTAL RISKS ASSOCIATED WITH THE ARMY'S PROPOSED STREAMLINED COMANCHE HELICOPTER PROGRAM

The membership of the COMANCHE Risk Review Panel is shown here. Mr. Pete Adolph, former Director of Test and Evaluation on the OSD staff served as chairman. The other outside experts included Mr. Dick Ballard, Professor Alfred Gessow, Mr. Lou Herrick, Mr. Matt McGuire, and Mr. Nic Torelli. The IDA project team assigned to assist the panel was led by Dr. L. Dean Simmons. Other IDA participants included Mr. Lucien Biberman, Mr. Bill Brykcznski, and Dr. David Sparrow.

ASSESSMENT PANEL

PETE ADOLPH, *PANEL CHAIRMAN*

L. DEAN SIMMONS, *IDA PROJECT LEADER*

DICK BALLARD
ALFRED GESSOW
LOU HERRICK
MATT MCGUIRE
NIC TORELLI

LUCIEN BIBERMAN
BILL BRYKCZNSKI
DAVID SPARROW

I. SCOPE AND APPROACH

The outline for the presentation is shown on this chart. The first section of the briefing describes the scope of the panel's efforts and the analytical approach that was employed in carrying out the assessment. Following this, the presentation describes the principal development alternatives considered by the panel. The results of the panel's assessment of the risk implications of the development alternatives are contained in the third section of the briefing. The principal conclusions and recommendations of the panel's assessment are reported in the briefing's final section.

OUTLINE

- SCOPE AND APPROACH
- DEVELOPMENT ALTERNATIVES
- ASSESSMENT OF RISK IMPLICATIONS
- CONCLUSIONS AND RECOMMENDATIONS

The scope of the panel's assessment is characterized on this chart. The panel began by reviewing the existing contracted development program and the Army's proposed "streamlined" program. Particular attention was paid to the funding profile proposed for the program, the number of prototype aircraft to be built and tested, the overall test plan including both developmental and operational tests, and the proposed production schedule.

The panel then reviewed the contractors' plans for developing and manufacturing the COMANCHE. Specific attention was paid to the manufacture and assembly of the prototype aircraft as well as to the contractors' plans for low-rate initial production and eventual full-rate production.

Following these activities, the panel then assessed the development risks associated with the proposed "streamlined" program. To carry out this assessment, the panel first identified the risks associated with the existing, contracted program.

Although the panel strongly supports the idea of seeking regulatory relief, a detailed review of this aspect of "streamlining" was considered beyond the scope of the panel's activities. Instead, the panel recommends that OSD seriously consider the detailed regulatory review conducted for the COMANCHE Program Office by Burdeshaw Associates.

In those cases where the panel assessed development risks to be too high, alternative approaches were identified.

SCOPE

- REVIEW ARMY'S PROPOSED ACQUISITION STRATEGY FOR COMANCHE
  - Funding Profile
  - Number of Prototype Aircraft
  - Test Plan
  - Production Schedule
- REVIEW CONTRACTORS' PLANS FOR
  - Manufacture and Assembly of Prototype Aircraft
  - Low-Rate Initial Production
  - Sustained Production
- ASSESS DEVELOPMENT RISKS ASSOCIATED WITH PROPOSED STREAMLINED PROGRAM
  - Identify Risks Associated With Existing, Contracted Program
  - Rely on Burdeshaw Study's Review of Regulatory Burden
- IF RISKS ARE CONSIDERED TOO HIGH, IDENTIFY ALTERNATIVE APPROACHES THAT COULD REDUCE PROGRAM RISK

The analytical approach adopted by the panel is illustrated schematically on this chart. To ensure that all aspects of COMANCHE development were reviewed at a comparable level of detail, the panel members investigated risks in the specific areas shown here. The assignments were determined based on the backgrounds of the indicated panel members. (The original makeup of the panel had been established with this type of comprehensive program overview in mind.)

APPROACH

OVERALL PROGRAM
- Adolph
- Ballard
- Simmons

AIRFRAME AND PROPULSION
- Gessow

PRODUCIBILITY
- Torelli

MISSION EQUIPMENT
- Biberman
- Sparrow

MANPRINT/TRAINING
- Herrick

SOFTWARE
- Brykczynski

TEST AND EVALUATION
- Adolph
- McGuire

SUPPORTABILITY
- Torelli
- McGuire

To conduct its assessment, the panel participated in the key visits and discussions identified on this chart. On June 28, 1994 the panel met with representatives from the Army's COMANCHE Program Office to discuss the proposed "streamlined" development program and to compare it with the traditional DEM/VAL-EMD approach. Following this, the panel visited the Boeing Helicopter facilities in Philadelphia and the Sikorsky Aircraft facilities in Trumball, Connecticut for detailed discussions with the two contractors that are jointly developing the COMANCHE.

On August 12, the panel was briefed in detail by Martin-Marietta on the development of the COMANCHE's electro-optical subsystem (EOSS). The EOSS is a key component of the helicopter's mission equipment package and its successful development is critical to achieving many of the operational performance goals projected for the helicopter.

On August 16, Mr. Jack Welch briefed the panel on the results of Burdeshaw Associates' review of the proposed "streamlined" program, focusing primarily on the various regulatory requirements that might reasonably be relaxed to reduce program costs. On that same day, the panel solicited the opinions of a number of well known experts in helicopter development -- Mr. Charles Crawford, former Technical Director at the Army Aviation Systems Command; Mr. Tom House, Executive Director at the Army Aviation Research, Development, and Engineering Center; and Mr. Robert McDaniel.

Representatives from the Army's COMANCHE Program Office returned to IDA for further discussions on August 18. They provided a revised "streamlined" program at that time and presented the proposed test plan for the aircraft.

KEY VISITS

• JUNE 28	COMANCHE PROGRAM OFFICE
• JULY 12, 13	BOEING HELICOPTER
• JULY 14, 15	SIKORSKY AIRCRAFT
• AUGUST 12	MARTIN MARIETTA
• AUGUST 16	BURDESHAW ASSOCIATES
• AUGUST 16	CHARLES CRAWFORD, TOM HOUSE, ROBERT MCDANIEL
• AUGUST 18	ARMY ON TEST PROGRAM
• AUGUST 18	COMANCHE PROGRAM OFFICE

II. DEVELOPMENT ALTERNATIVES

This section of the presentation characterizes the alternative development approaches considered by the panel. The existing, contracted development is discussed first, after which the Army's proposed "streamlined" development is examined.

OUTLINE

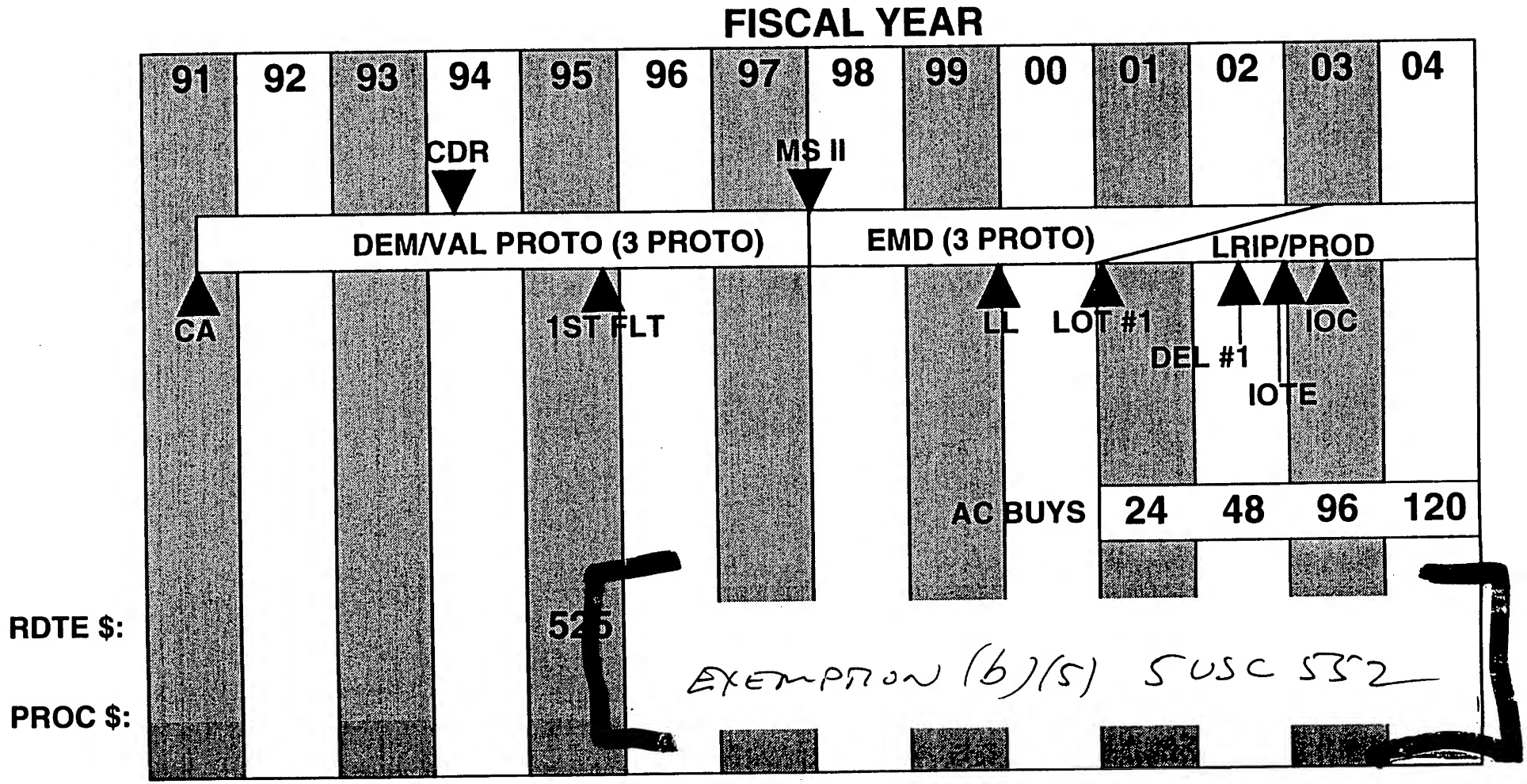
- SCOPE AND APPROACH
- DEVELOPMENT ALTERNATIVES
  - Existing Contracted Development
  - Streamlined Development
- ASSESSMENT OF RISK IMPLICATIONS
- CONCLUSIONS AND RECOMMENDATIONS

This chart shows the schedule and funding profile for the existing, contracted COMANCHE development program. Actually, only the DEM/VAL phase is currently under contract. If this development plan were continued, the Army's COMANCHE Program Office and the Boeing-Sikorsky Joint Program would soon need to begin negotiating a contract for the EMD phase of development.

As indicated on the schedule, this program features three prototype aircraft built and tested during the DEM/VAL phase, with first flight of the first COMANCHE prototype scheduled for November 1995. Three additional prototypes would be built and tested during the EMD phase. At the conclusion of DEM/VAL and prior to the award of the EMD contract, a Milestone II review would be held for the program. Long-lead production would begin at the end of FY 1999 and the first 24 production aircraft would be funded in FY 2001. Plans call for production to ramp up to 48 in FY 2002, to 96 in FY 2003, and to the full production rate of 120 per year by FY 2004. The first production aircraft would be delivered to the Army in mid FY 2002. The Initial Operational Test and Evaluation (IOTE) would be held early in FY 2003. Initial Operating Capability would be achieved by mid FY 2003.

The proposed funding profile is shown the bottom of the schedule. Separate lines are shown for research, development, test, and evaluation (RDTE) funds and f procurement funds. All dollar amounts shown are millions of then-year, or escalated, dollars.

EXISTING CONTRACTED DEVELOPMENT PROGRAM



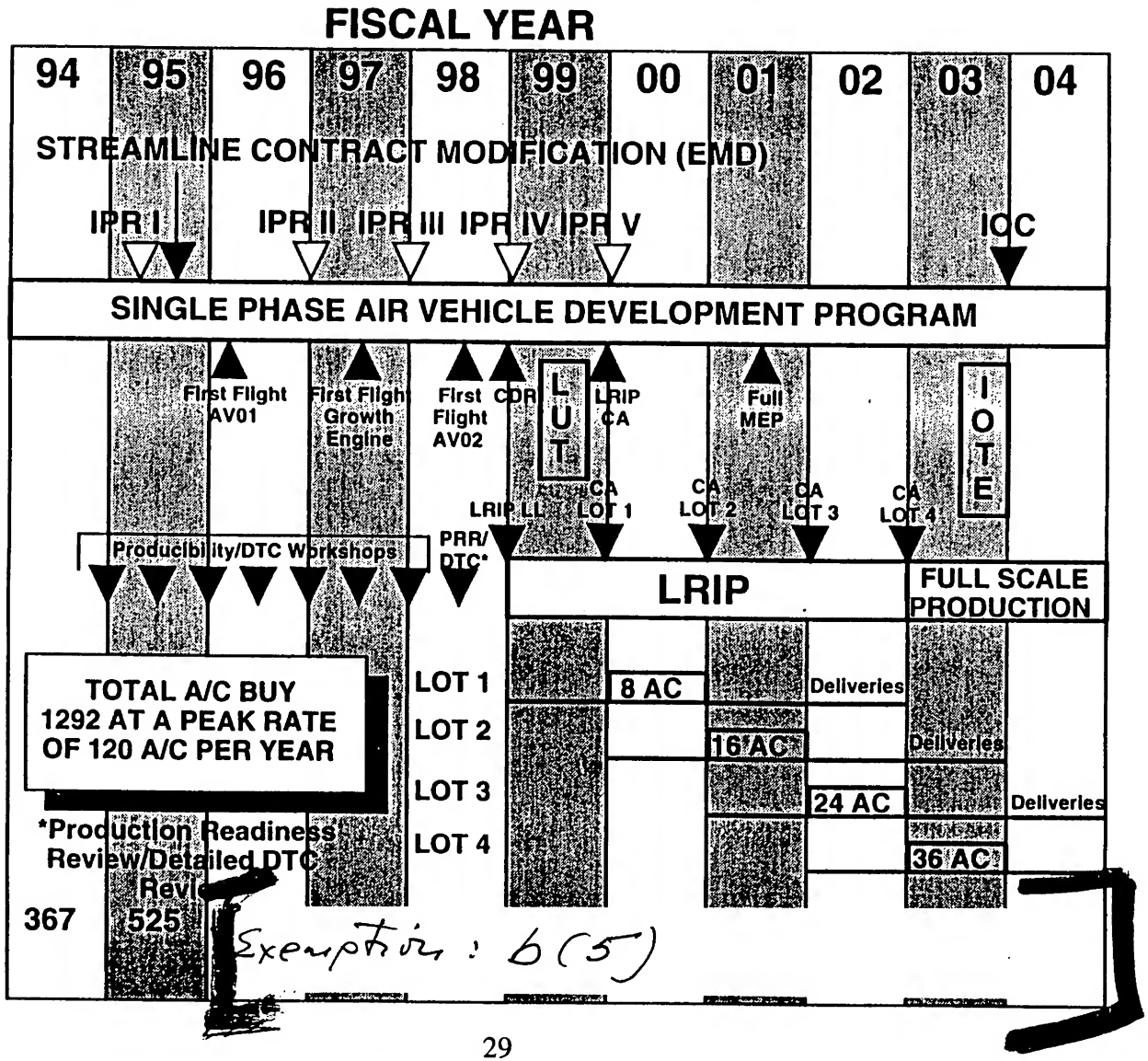
The schedule for the "streamlined" development program proposed by the Army is shown on this chart. Under this plan, in May 1995 the Army would modify the existing COMANCHE development contract to incorporate the activities normally conducted during EMD into a new single-phase development program. The first flight of the first of two DEM/VAL prototypes would occur in early FY 1996, several months later than was proposed under the existing development contract. The first flight of the second DEM/VAL prototype would not occur until late FY 1998, nearly 2 1/2 years after the first flight of the first prototype. The next three prototypes would be taken from the first lot of eight Low-Rate Initial Production (LRIP) aircraft. These prototypes would be delivered to the Army during FY 2002.

In comparison to the Army's previous plan for COMANCHE development, the "streamlined" plan initiates production one year earlier, but at a significantly slower rate. In the first year (FY 2000), only 8 aircraft would be built; in the second, 16 aircraft; in the third, 24 aircraft; and in the fourth (FY 2003), 36 aircraft.

OSD oversight for this program would be accomplished through a series on In-Process Reviews (IPRs), the first of which would occur early in FY 1995 prior to the award of the modified development contract. Beginning at the end of FY 1996, in-process reviews would be scheduled annually to enable OSD to track prog development.

Finally, as indicated on the chart, the funding prc for the proposed "streamlined" program is the same as currently planned for the existing program.

STREAMLINED DEVELOPMENT PROGRAM



The principal features of the Army's proposed "streamlined" development program are summarized on this chart. First, the "streamlined" program retains the existing technical requirements for COMANCHE. In addition, the proposed "streamlined" program retains the current program funding schedule.

To enable more efficient development, the "streamlined" program integrates the current DEM/VAL and EMD phases into a single development phase. OSD oversight for the program would occur primarily through periodic in-process reviews rather than through milestone reviews.

Developmental testing for COMANCHE would be accomplished using five prototype aircraft rather than the six proposed in the DEM/VAL-EMD approach. Of these five, the first two would be built during the development phase and the next three would be taken from the first lot of LRIP. The first flight of the second prototype would occur well over 2 years after the first flight of the initial prototype. Following testing, the three LRIP aircraft would be refurbished and delivered to the Army as production aircraft.

To further reduce costs, the Army proposed to reduce flight test hours from the 1,900 hours planned prior to LRIP under the DEM/VAL-EMD approach to only 600 hours. Increased use would be made of the contractors' simulation facilities in order to compensate for the reduction in flight test hours.

Additional reductions in program costs would be attained by securing waivers from selected DoD regulations and policies.

Finally, the first three lots of LRIP would be funded incrementally rather than as a single item. This change would also require a waiver from existing regulations.

OVERVIEW OF ARMY'S STREAMLINED PROGRAM

- RETAINS EXISTING TECHNICAL REQUIREMENTS FOR COMANCHE
- RETAINS CURRENT PROGRAM FUNDING SCHEDULE
- INTEGRATES CURRENT DEM/VAL AND EMD PHASES
- REPLACES MILESTONES WITH EVENT-DRIVEN IN-PROCESS REVIEWS
- PROPOSES DEVELOPMENTAL TESTING USING TWO PROTOTYPE AIRCRAFT PROCURED DURING DEVELOPMENT PHASE AND THREE LRIP AIRCRAFT BOUGHT WITH PROCUREMENT FUNDS
- DECREASES ACTUAL FLIGHT TEST HOURS BY INCREASING RELIANCE ON SIMULATION
- REQUIRES WAIVERS FROM SPECIFIC DoD REGULATIONS AND POLICIES
- INCREMENTALLY FUNDS FIRST THREE LOTS OF LRIP

III. ASSESSMENT OF RISK IMPLICATIONS

The next section of the presentation summarizes the panel's assessment of the developmental risks associated with each major aspect of COMANCHE development. A common format has been employed in order to clarify the presentation. For each of the key program aspects, we have first identified the development risk that would be incurred if COMANCHE development were to proceed under the existing contracted approach. We then identify how those risks would most likely be affected by the Army's proposed "streamlined" approach. Where appropriate, additional amplifying information is provided.

OUTLINE

- SCOPE AND APPROACH
- DEVELOPMENT ALTERNATIVES
- ASSESSMENT OF RISK IMPLICATIONS
  - Airframe and Propulsion
  - Mission Equipment
  - Software
  - Producibility
  - Test and Evaluation
  - Manprint/Training
  - Supportability
- CONCLUSIONS AND RECOMMENDATIONS

The COMANCHE's airframe and propulsion system is made of a number of subsystems that individually and collectively determine the basic air worthiness and flight performance of the helicopter. Although many of these systems incorporate significant advances in rotorcraft technology, their development is based on a well-researched database, advanced analyses, and applicable experience with like systems. Thus, past risk assessments, as well as the current one that considered the existing contracted development program, assessed the risk for each individual subsystem in the airframe and propulsion category as low to moderate. With few exceptions, in the panel's view, "streamlining" should impose little additional risk on the individual subsystems.

It must be recognized, however, that to a greater extent than with fixed-wing aircraft, significant interactions among the individual subsystems can adversely affect the behavior of the helicopter as a whole. Examples that can be cited include main rotor/tail rotor or main rotor/empenage interference, and dynamic coupling between the main rotor and the airframe or the landing gear.

Because many of the COMANCHE's airframe and propulsion subsystems have seen little or no operational use in production helicopters, the effect of their interactive behavior on the overall helicopter system can on determined by extensive flight tests.

AIRFRAME AND PROPULSION SUMMARY

- RISK OF INDIVIDUAL SUBSYSTEM IN EXISTING, CONTRACTED PROGRAM IS LOW TO MODERATE
- STREAMLINED PROGRAM IMPOSES LITTLE ADDITIONAL RISK ON EACH SUBSYSTEM
- MANY SUBSYSTEMS REPRESENT ADVANCED, OR NEW-TO-THE-CONTRACTORS, TECHNOLOGIES THAT MUTUALLY INTERACT
- THE INDIVIDUAL AND INTERACTIVE PERFORMANCE OF THESE SUBSYSTEMS CAN ONLY BE EVALUATED DURING FLIGHT TESTS FOR ENTIRE SYSTEM

Among the interactive effects that might show up during flight testing with potentially adverse effects on program schedule or cost are the following:

1. The bearingless main rotor, with its equivalent high flapping-hinge offsets and soft in-plane dynamic characteristics, can transmit high vibratory loads to the airframe. Careful matching of the rotor/airframe coupled dynamic frequencies and damping are required to avoid catastrophic ground or air resonances. A key challenge with such rotors is to provide in-place lag dampers that generate the damping needed.

2. The horizontal tail surface plays a key role in providing the helicopter with desired stability and control characteristics. Such surfaces, however, are subject to complex flows that vary with time and flight condition, and emanate from the wakes of the main and tail rotors, and sometimes the rotor hub itself. Past development experience with such helicopters as the APACHE, BLACKHAWK, and the EH-101 involved costly post-flight changes in the location and design of the tail surface. Again, only flight tests will reveal if the "lessons learned" in previous developments will enable the COMANCHE to avoid this problem.

3. The main rotor transmission limits the aircraft's ability to accommodate unplanned for increases in engine power or helicopter weight.

4. The capability of the flight control system to adjust flight-measured handling qualities so as to match simulator values and meet specifications must be established. Extensive ground simulator studies have been conducted to ensure that the handling qualities of the COMANCHE will meet Mil Specs; more studies are planned. The simulator studies are based on predicted rotor and airframe characteristics. Once actual flight measurements are made, the flight control system will have to adjust these characteristics with a minimum cost or schedule delay.

5. The close proximity of the main rotor to the airframe may introduce adverse aerodynamic effects. If these effects are severe and cannot be handled by other means, it may require the rotor to be raised relative to the airframe.

AIRFRAME AND PROPULSION SUMMARY (Cont'd)

- AREAS WITH POTENTIAL ADVERSE IMPACT ON SCHEDULE AND COST INCLUDE:
  - Effects of Bearingless Main Rotor on Vibration and Air Resonance (Dependent on In-Plane Dampers)
  - Location and Effectiveness of Horizontal Tail Surface
  - Main Rotor Transmission Limits on Ability of Growth Engine to Handle Unplanned Empty-Weight Increases (e.g., Need for Active Vibration Control System)
  - Unanticipated Rotor/Airframe Interference Effects
  - Handling Qualities (Includes Control) Characteristics That Differ Significantly From Those Used in Ground Simulator Tests

Detailed assessments of the risks associated with the airframe and propulsion subsystems are reported on the next five charts. For most of the subsystems, the risk under the existing development program is assessed to be low, subject, as discussed previously, to interactive phenomena that may be revealed during flight testing. The Army's proposed "streamlined" approach should impose little adverse risk on most of these subsystems.

There are exceptions, however. In the case of secondary systems (icing) and handling qualities, the "streamlined" schedule introduces additional risk by reducing or deferring flight testing. In the case of the radar signature, the effective performance can be determined only by tests of the all-up aircraft. A similar comment can be made with respect to ballistic vulnerability, for which full-up COMANCHE airframe tests are not scheduled until FY 2002.

It is difficult to assess the risk impacts of LONGBOW integration on COMANCHE, because of that program's dependence on APACHE LONGBOW and the fact that the necessary wind tunnel and flight tests remain unspecified. Nevertheless, the integration effects on airframe drag, performance, handling qualities, and vibration should be anticipated by analysis and limited tests.

AIRFRAME AND PROPULSION

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Composite Fabrication	Low: Parts, Quality, Fit and Assembly Times Meet All Expectations	No Adverse Impact	Extensive Contractor Experience and Emphasis on Composite Manufacture and Use Minimizes Risk
Main Rotor System	Low: Extensive Analyses and Laboratory, Wind Tunnel and Flight Tests Complete	No Adverse Impact	BMR (Bearingless Main Rotor) is a Departure From Traditional Contractor Designs. Cost and Schedule Would Be Impacted if Problems Arise in Flight Tests
Anti-Torque System	Low: Extensive Analyses and Ground Tests Completed, as Well as Successful Flight Demonstrations	No Adverse Impact	Conservative Design

AIRFRAME AND PROPULSION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Secondary Systems	Low: Supplied by Quality, Proven Vendor Sources With Awareness of Lessons Learned in Other Development Programs	Some Increased Risk	Icing Flight Tests Eliminated in Favor of Increased Wind Tunnel Tests
Flight Performance	Low: Extensive Model and Full-Scale Wind Tunnel Tests	No Adverse Impact	Emphasis on RCS Reduction Minimizes Likelihood of Future Drag Increases
Flight Handling Qualities	Low: Extensive Ground Simulation, With Some Flight Verification Completed	Slight Adverse Impact Because of Reduced Flight Testing	Cost and Schedule May Be Impacted If Problems Arise in Flight Tests

AIRFRAME AND PROPULSION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Radar Signature	Moderate: 4500 Hours of Range Tests Completed, but Effects of Contours, Steps, and Gaps To Be Evaluated	Potential Adverse Risk: Early Assessment of Prototype Aircraft Scheduled, With Flight Tests Completed Approx 40 Months Prior to LRIP Flight	First Full-Scale Tests Exceeded DEM/VAL Requirements. May Need To Fine Tune RCS On All Up Aircraft
IR Signatures	Low: Exhaust Design Proven in Full-Scale Tests	No Adverse Risk	
Vulnerability	Moderate: Component Ballistic Design - Support Testing Completed; Ballistic Tests of Propulsion, Anti-Torque and Main Rotor To Be Completed by FY 97	Some Increased Risk: Vulnerability Evaluated After 1st LRIP Flight	Test of Full-Up COMANCHE Airframe in FY 02
NBC Protection	Low	No Adverse Risk	

AIRFRAME AND PROPULSION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Engine	Low: T-800-LHT-800 Army Qualified and FAA Certified. T-800-LHT-801 Tests Ahead of Schedule; IRP Specs Exceeded by 50 SHP	No Adverse Risk	First Flight of Growth Engine Approx 48 Months Before Delivery of First LRIP Aircraft. Further Growth Limited By Transmission
Engine Integration	Low: Early Analyses and Design Support Tests Successful	Some Increased Risk: Full Flight Qualification Tests Delayed	475 Hours of Propulsion System/Drive Train Test Bed Tests Scheduled Before LRIP Contract
Longbow Integration	Moderate: Schedule at Risk Because of Dependence on Success of APACHE LONGBOW. Effect of Antenna on Drag, Weight, Loads and Controls Requires Wind Tunnel and Flight Tests	Adverse Risk	Uncertain Schedule for Full-Scale Wind Tunnel and Flight Tests

AIRFRAME AND PROPULSION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Air Vehicle Crew Station	Low to Moderate: Low on All Factors Involving Physical Layout; Moderate on Control and Pilot Workload Factors	No Adverse Risk Because Flight Evaluation Performed on Prototype Aircraft	
Weight Empty	Low to Moderate: With Design Essentially Complete, Weight Specs Exceeded by Only 0.4%	No Increased Risk	Very Limited Margin; Historically, Growth Has Been Significant; Weight Control Continuously Tracked by Contractors' PDTs

The most challenging aspects of the MEP, and the aspects most likely to be adversely affected by "streamlining," are the integration effort -- the cockpit integration and development of the integrated mission support system. Developing the MEP subsystems should be only minimally affected by "streamlining." Integration frequently encounters unanticipated difficulties. The proposed "streamlining" does not allow sufficient time for testing, or allow for adequate user involvement in the integration phase. The panel rates this as the most crucial issue, because the integration must be done right in order to achieve the combat effectiveness projected for the COMANCHE.

Of the MEP components, the most critical and challenging is likely to be the Electro-Optical Sensor Suite (EOSS). The risks associated with this system are driven by technical challenges and should be relatively unaffected by "streamlining." These technical challenges often result from constraints on the design derived from specifications having nothing to do with the sensor's optical performance. The impact of these specifications, such as RCS and optical counter-countermeasures, should be tradable at the subsystem level as well as the airframe level.

Finally, the test and development resources for the armament subsystems were severely reduced in the Army's original "streamlined" development approach. This is troubling because the contractors acknowledged the difficulties of the remaining challenges. There is considerable history of post-fielding difficulties with helicopter-mounted gun systems.

MISSION EQUIPMENT SUMMARY

- COCKPIT INTEGRATION AND INTEGRATED MISSION SUPPORT ARE THE MEP ELEMENTS OF GREATEST CONCERN
  - Proposed Streamlined Development Includes Inadequate Test Resources and User Involvement
- RISKS FOR THE TARGET ACQUISITION/NIGHT PILOTAGE SYSTEM ARE DRIVEN BY TECHNICAL CHALLENGES, AND ARE RELATIVELY UNAFFECTED BY STREAMLINING
  - Many Fixes Are Already Under Discussion
  - RCS Impact on Subsystems, Including EOSS, Should be Tradeable if "Too Hard"
- TEST AND DEVELOPMENT RESOURCES FOR ARMAMENT SUBSYSTEM ARE REDUCED BY STREAMLINING, THEREBY INCREASING RISK

The major risk in the target acquisition system seems to be to the schedule. The panel is concerned that the commitment to use beryllium aluminum (BeAl) in the EOSS casting is premature. The materials characterization of BeAl is still incomplete. If the design takes advantage of the greater stiffness of BeAl rather than aluminum, it will be difficult to return to aluminum if problems with the BeAl properties are uncovered. There may also be risks associated with the prospect of environmental regulation of beryllium.

The low light level TV for pilotage is being moved from the helmet to the nose of the aircraft. This expensive redesign of the optical system provides badly needed relief for the helmet weight, and probably much improved optical performance. However, the arrival of the hardware and software to support this design change has been delayed. The use of the central processor to relay images leads to an unacceptable 100 ms lag between a scene's true occurrence and the time the image is displayed. According to the COMANCHE Program Office, the image latency problem is currently being addressed.

The navigation and communication gear appears to carry little risk. The one possible exception to this is the desire for image transmittal as part of the Army's digitization program, for which this platform is a critical element.

MISSION EQUIPMENT

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Target Acquisition System	Low-Medium Major Risk Area is Schedule	Minimal Impact	BeAl Materials Development Underway; Commitment Seems Premature
Night Vision Pilotage Helmet Mounted Display	Low-Medium	Minimal Impact	Expensive Redesigns of Hardware in Progress; Latency Due to Central Processing Remains an Issue
Navigation/ Communication	Low	Increased Schedule Risk	Relatively Straightforward Not Many Changes, and They Are Starting Soon

As mentioned in the summary, the risk in cockpit integration is high. The reduced test resources associated with "streamlining" will exacerbate this situation. The risk of cost growth will be increased due to the increased probability (and number) of retrofits late in development. Perhaps more seriously, the system's combat performance is put at risk because of the grossly inadequate user time in the cockpit.

The development of the integrated mission support system is another area critical to capturing all the subsystem capabilities on the platform as it operates in combat. "Streamlining" will increase this risk. The contractors' experience is limited. COMANCHE software development is a huge undertaking, made more difficult for an "integrated" support system when the MEP arrives piecemeal, and the full-up MEP arrives quite late in the development.

The program has, wisely, eliminated the high risk survivability enhancements from the core package. The integrated equipment, such as radar warning receivers, is assessed to have low risk. The jamming systems, for which "provisions" have been made, are high risk developments that are being carried out independent of the COMANCHE program. The effect of "streamlining" is minimal. The easy tasks will be done anyway; the hard tasks are all provisional.

MISSION EQUIPMENT (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Cockpit Integration	High	Performance and Cost Risk Increased	Grossly Inadequate User Cockpit Time
Integrated Mission Support System	Moderate	High	Limited Contractor Experience; Software Development Is Huge; Full-Up MEP Too Late in Schedule
Aircraft Survivability Equipment	Integrated Equipment Is Low Risk; Provisional Equipment Is High Risk	Minimal Impact	Current Program Has "Provisions for" Jammers Which Are Not Likely To Ever Be Included

LONGBOW integration into COMANCHE is a difficult and high risk undertaking. It was difficult to integrate on the APACHE. It will have to be largely re-engineered to go on COMANCHE. There is, at present, little or no funding for this effort. Any attempt to preserve the stationary target capability of the LONGBOW APACHE system with a smaller antenna for COMANCHE would entail a major program of modifying algorithms and possibly waveforms. None of this has been faced.

COMANCHE armaments appear to be a low priority area. With the reduction of test resources devoted to the armaments, the risk in this area increases significantly. The panel is troubled by the fact that a number of problems have been found in the armaments area, but in all cases of which we are aware the fixes have been deferred for several years.

MISSION EQUIPMENT (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
LONGBOW Integration	High	None	There Is Little or No Funding for This Effort. The Planned Integration Is Actually for a New (Smaller) System on a New Platform. Longbow Performance and Value Added Remain Controversial
Armament	Low	Increased to Moderate	This Appears To Be a Low Priority Area, Yet Problems in Armament and Armament MEP Have Been Found

Despite verbal assurances that the Army has firmly decided to include LONGBOW on COMANCHE, there is evidence of ambivalence. There are essentially no future resources devoted to the integration of LONGBOW on COMANCHE. Furthermore, the system will not be added until the fifth production lot.

The panel believes that this perceived ambivalence is appropriate. Many studies have indicated, especially for the anti-armor role, an enormous increase in effectiveness when using a system with the rapid battlefield search and target servicing that LONGBOW with the upgraded HELLFIRE missile is intended to provide. Unfortunately, these studies have mostly assumed an advancing numerous, technically advanced foe, and neglected the possibly of fratricide, a set of assumptions designed to maximize LONGBOW's modeled value.

Since these studies have been done, the LONGBOW specifications, especially for the stationary target mode, continue to drop, even for the full-size system. The testing of the system has been essentially closed to outsiders, suggesting a lack of robustness in the performance. The user community has accepted a reduction in performance requirements against stationary targets and a "benign conditions" caveat has been added to the requirement as an additional limitation. A smaller antenna would have significantly higher false alarm rates, and probably require substantial missile software changes in order to make the navigation work. Without assuming any necessary platform-specific changes to the missile, the forecast missile costs continue to grow.

In summary, even if all the specifications of the LONGBOW system on APACHE are met, little combat value will be added by fitting a reduced capability LONGBOW on a low signature air vehicle equipped with a focal place array FLIR. It is by no means certain that desired LONGBOW specifications can be met for APACHE. A daunting integration task remains before LONGBOW can be moved to COMANCHE, even if all goes well on APACHE.

LONGBOW ISSUES

- THE ARMY APPEARS (APPROPRIATELY) AMBIVALENT ABOUT THE VALUE ADDED TO COMANCHE
  - There Are No Programmed Resources To Integrate LONGBOW Into Either the Airframe or MEP
  - The System Is Only To Be Added in Production Lot 5

- WE BELIEVE THE ARMY'S AMBIVALENCE IS APPROPRIATE BECAUSE:
  - Attaining Specified LONGBOW Performance Goals Would Substantially Enhance Operational Effectiveness

- ON THE OTHER HAND,
  - Performance Specifications Continue To Drop for the Full Size System
  - Testing Has Been Essentially Closed to Outsiders
  - The Smaller FCR Will Have Increased False Alarms Against Stationary Targets
  - The Smaller FCR Will Probably Necessitate a Missile Software Rework
  - Missile Costs Continue To Grow
  - The Combat Value Added in Placing a Reduced Capability LONGBOW on a Reduced Signature Vehicle With a 2nd Gen FLIR is Likely To Be Small Compared to the Value Added of the LONGBOW APACHE Program, Even if All Specifications Are Met

The COMANCHE program is one of the Army's largest embedded single-platform software development efforts to date. Nearly three million source lines of code are currently estimated for the total program, of which about half will be onboard the aircraft. With over 90 percent of the software being written in Ada, it is also one of the DoD's largest Ada efforts as well.

The impact of the proposed streamlining approach on software development is assessed to be minor, primarily because the pre-streamlining schedules lacked sufficient definition. A large portion of the pre-streamlining software development was simply deferred until EMD. The streamlined schedules continue to defer some software development (in this case, into the production phase), but most functionality has been assigned into four groups: Core, Design Releases 1 and 2, and the Production Upgrade. The more challenging software components (e.g., FLIR, NVPS, TAS) are found in Design Releases 1 and 2.

Design Release 2 is scheduled for completion in late FY 1999. There will be limited flight testing of this software before the LRIP contact award, which is in early FY 2000. The functionality within Design Release 2 is considered complex, and the likelihood of encountering difficulties is high. Thus, demonstrations of Design Release 2 functionality are likely to be delayed for the first LRIP aircraft.

SOFTWARE SUMMARY

- COMANCHE PROGRAM INCLUDES SUBSTANTIAL SOFTWARE DEVELOPMENT
  - 2.6 Million SLOC of Which 1.2 Million Are on the Aircraft
  - Over 90 Percent To Be Coded in Ada
- IMPACT OF STREAMLINING ON SOFTWARE DEVELOPMENT SCHEDULES APPEARS MINOR. MAJOR CHANGES IN STREAMLINED PROGRAM INCLUDE:
  - Software Development Allocated to Several Releases (i.e., Core, Design Releases 1 and 2, and Production Upgrade)
  - More Challenging Components Are in Design Releases 1 and 2 (e.g., FLIR, NVPS, TAS)
  - Production Upgrade Functionality Deferred Until After IOC (e.g., Tactics Expert Function, On-Board Training, Prognostics, MEP Enhancements)
- LIMITED FLIGHT TESTING OF DESIGN RELEASE 2 MEP SOFTWARE OCCURS PRIOR TO LRIP CONTACT AWARD

Several aspects of COMANCHE functionality that had been previously deferred until EMD have been moved to the Production Upgrade release, which occurs after IOC (i.e., far into LRIP). This functionality includes the LONGBOW software, tactics expert function, on-board training, prognostics, and various MEP enhancements (i.e., perspective map, voice warning, SATCOM, digital messaging enhancements, integrated fire and flight control, and image intensification on the nose). Backfitting this software during the production phase may be very costly as it is likely to require significant modification to existing software.

The COMANCHE program will be required by Army policy to periodically produce a series of software metrics, known as the Software Test and Evaluation Panel (STEP) metrics. There are 12 STEP metrics that cover areas such as cost, schedule, processor usage, testing, and process maturity. In examining the metrics being collected and reported by the COMANCHE program, most of the STEP metrics are being addressed. Clearly, the COMANCHE program is operating within the spirit of the STEP policy. The major exception is the Software Engineering Environment metric, which measures a contractor's software processes maturity using a model such as the Capability Maturity Model. The COMANCHE program has little formal software process maturity efforts underway.

SOFTWARE SUMMARY (Cont'd)

- MUCH SOFTWARE HAD BEEN "DEFERRED UNTIL EMD" WITH NOMINAL SCHEDULE PLANNING
  - About Half (730 KSLOC) of Air Vehicle Software Will Be Developed During DEM/VAL
  - About One Third (870 KSLOC) of Total Software Will Be Developed During DEM/VAL
- BOEING/SIKORSKY AND THEIR SUPPLIERS ARE REPORTING SOFTWARE METRICS THAT ARE SUBSTANTIALLY SIMILAR TO THE STEP METRICS

Detailed assessments of the risk associated with the COMANCHE's software are reported on the three following charts. For most aspects of software development, the risk under the existing development program is assessed to be moderate or moderate to low. "Streamlining" is expected to have little or no impact on software development risk.

SOFTWARE

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT*	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
TAS/NVPS	Moderate	-	
Controls & Displays	Moderate to Low	Minor	Majority of C&D Software is Needed for First Flight. Delayed by Several Months
Flight Controls	Moderate	Minor	Majority of Flight Control Software is Needed for First Flight. First Flight Delayed by Several Months
Embedded Processing	Moderate	-	
Nav/Com/ID	Moderate to Low	None	Estimated 64 KSLOC. Fire Control Algorithms Considered Complex, No Risk Reduction Activities Evident. Scheduled for Design Release 2

*These Values Were Derived From the April 1991-August 1992 COMANCHE Risk Assessment.

SOFTWARE (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Armament	Moderate to Low	Low	Estimated 64 KSLOC. Fire Control Algorithms Considered Complex, No Risk Reduction Activities Evident. Schedule Moved Up to Design Release 2
Aircraft Survivability Equipment	Moderate	None	Estimated 110 KSLOC, Moderate/High Complexity, Little Risk Reduction Activities Evident. Partial Development in Design Release 2
Training	Moderate	None	Remains Deferred Until After IOC
Mission Planning	Moderate	None	Scheduled for Design Release 2

*These Values Were Derived From the April 1991-August 1992 COMANCHE Risk Assessment.

SOFTWARE (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Integrated Support Activity	Low to Moderate	None	
Depot Support	Low to Moderate	None	Remains Deferred Until After IOC. Depot Support Software Development May Continue into Production Phase
Maintenance Support	Low to Moderate	None	Remains Deferred Until After IOC

*These Values Were Derived From the April 1991-August 1992 COMANCHE Risk Assessment.

The Boeing/Sikorsky Team's use of a CAD/CAM fully interactive data system has saved significant costs, reduced errors, and enabled more rapid transition to production than was the case for classic paper designs. The concept of integrated product development teams maximizes the interaction of all disciplines concerned with the COMANCHE program during the life cycle, including the manufacturing, reliability, and maintainability engineers. These concepts have significantly reduced the assembly times of the first two airframes; this is expected to save additional costs over the life of the program.

The risks associated with composite manufacture for COMANCHE are assessed to be low to moderate, especially when compared to the much more difficult composite work on B-2, F-22, and A-12. The contractors appear to be under reasonable control with hard tooling in place. Their planning and execution is near or ahead of schedule and very close to their cost goals. The only potential problem is with the low observable composites manufactured for Boeing by HEXCEL Corporation. HEXCEL is currently in Chapter 11 bankruptcy proceedings, but a resolution is expected within the next few months. The "streamlined" program would enable the primes to put in place more innovative ways to cut composite manufacturing costs (e.g., an "automated pick-and-place" type machine for the lay-up of the composite strips, similar to the pick-and-place devices associated with circuit card assemblies).

In the panel's view, the most difficult producibility issues are those associated with the electro-optical sensor suite. The EOSS presently has 10 application specific integrated circuits (ASICS) designed into it. A recent change takes a significant amount of the processing intended for the central computer and moves it to the EOSS to enhance the operator interface -- specifically the time delay in data presentation in the cockpit incurred by central computing. This requires an additional 10 or so new ASICS to be designed and built. Martin Marietta had an extremely difficult time getting through the design process initially (with major cost and schedule overruns). They believe that they have satisfactory "lessons learned" from that experience to more properly oversee this new (and expensive, but necessary) development effort. This project is critical to enhance the operator performance, but it must be planned for and executed with more attention to detail than the previous effort.

PRODUCIBILITY SUMMARY

- BOEING/SIKORSKY TEAM'S USE OF DIGITAL (CAD/CAM) DATA BASE AND INTEGRATED PRODUCT DEVELOPMENT TEAMS SIGNIFICANTLY REDUCES RISKS IN TRANSITION TO PRODUCTION
- COMANCHE COMPOSITE STRUCTURES ARE LESS COMPLEX AND LESS RISKY THAN RECENT AIRCRAFT PROGRAMS (TEAM HAS CAPITALIZED ON LESSONS LEARNED)
- MOST DIFFICULT PRODUCIBILITY ISSUES ARE AT MARTIN MARIETTA ON THE ELECTRO-OPTICAL SENSOR SUITE (COMPONENT/ASSEMBLY PACKAGING, BERYLLIUM ALUMINUM CASTINGS, APPLICATION SPECIFIC ICs, OPTICAL WINDOWS)

The concept for Standard Electronic Modules (SEM - E) under development by Westinghouse is very sound. They have invented a no-solder connection technique to attach components to the circuit board or base plane. This concept reduces the military specification requirements (no soldering spec). Also, the risk for replacing damaged or dysfunctional parts is minimized by not requiring the application of heat during parts removal.

The use of Beryllium Aluminum (BeAl) in place of aluminum castings will save about 40 pounds in weight in the nose of the aircraft. This must be traded with the risks of using an unproven material (BeAl) in this type of application. There are Manufacturing Technology projects and company-funded research and development going on at Martin Marietta and their vendor (Nuclear Metals), but these efforts are proceeding concurrently with their plan, which is to use BeAl now. Their "drop-dead" point for deciding against BeAl in favor of the less risky aluminum occurs in early 1995; it is unlikely that enough work will have been accomplished in the validation of the material for use by then.

The optical windows for the EOSS are very complex to manufacture and are very expensive (roughly $200K per system). The present design is based on Army requirements that must be reexamined before any commitment is made to mandate the manufacture of these windows. The real question that must be answered is, "How real is the requirement of the low observability specification when compared to the exorbitant cost of these special windows?"

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Additional details regarding the panel's assessment of producibility risk are reported on the two following charts. Most of the key points regarding these risk elements have already been discussed, with the exception of overseas sources. In that regard, there are several foreign contractors involved in sole-source arrangements for specialized parts for the EOSS. They include AEG-Telefunken (Germany) for the electro-optic cooler with embedded electronics and El Op (Israel) for the laser rangefinder. The proposed "streamlined" program should try to obtain specification relief from the Buy-American Act, and whatever other laws or specifications require the cultivation of domestic sources. These costs of competition must be evaluated as compared to the cost of sole-sourcing available technology in the global marketplace.

PRODUCIBILITY

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Composite Manufacturing (General)	Low to Moderate - Appears To Be Under Control at Both Prime Contractors	Little Effect - Affords More Time To Automate Processes for Fuselage Lay Up and Assembly	None
Composite Manufacturing	HEXCEL Critical Sub to Boeing Is in Chapter 11; To Be Resolved Soon	No Effect	No Other U.S. Source
Application Specific Integrated Circuits (Martin-EOSS)	Low-to-Moderate, Has Been a Very Difficult Developmental Process	Roughly Doubles the Number of ASICS-- Moderate-to-High Risk	Must Be Done To Improve EOSS-User Interface
SEM-E Modules (Westinghouse)	Low-to-Moderate Risk - Good Concept, Appears To Be Under Control	No Effect	None

PRODUCIBILITY (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
BeAl Castings (Martin-EOSS)	New Application for BeAl - Plan Is Reasonable, but the Proofing of BeAl Is Moderate-High Risk; Potential Health/ Environmental Concerns	Little Effect	Any Consideration of Contingency Plan for Aluminum Only ?
Optical Windows (Martin-EOSS)	Moderate Risk - Very Complex and Expensive Manufacturing	No Effect	Principally Cost vs. Requirements Issue
Allied Sources	Spec/Law Related (e.g., Buy American Act); Not Technical or Manufacturing Issues	No Effect	Must Evaluate Costs of Competion

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MEP

The Army's "streamlined" approach postpones the full MEP evaluation once planned during the limited user test (LUT) and does not achieve an aircraft evaluation of full MEP until 1 year after LRIP contract award. Consequently, there are no test events to support a conclusion that MEP is ready for IOTE. Late development of MEP delays the discovery of hardware integration and software problems. *Delaying the required maturity until well after LRIP contract award is not a prudent risk management approach.*

RELIABILITY AND RELIABILITY GROWTH

Expected reliability growth at LUT is 40-50 percent, and only 65 - 80 percent at IOTE. Full reliability growth is not expected to be achieved until IOC + 2 years.

Delayed demonstrations and evaluations of critical reliability criteria results in reduced insight into COMANCHE design maturity. Commitment to Full Rate Production before reliability growth achievement increases the risk of producing an immature design.

Diagnostics maturity is critical to an accurate assessment of the proposed two-level maintenance concept. The delay in Block II and III software development will prevent proper maturity of the diagnostics capabilities essential for proper fault detection and resolution of the supportability concept.

OTE

Previously, the program provided adequate flight test (over 300 hours) and simulator hours to form an Operational Assessment in support of the LRIP Contract Award. The streamlined program has deleted the scheduled early user test (EUT) , a test consisting of 3 aircraft and 300 flying hours, designed to support the MS IIIA review prior to LRIP Contract Award.

The "streamlined" program proposes only 24 flight hours for LUT, does not evaluate Full MEP or Block III hardware and software during LUT, and reduces the flight test program to 2 prototypes.

The proposed flying hour program is not sufficient to assess readiness for IOTE, and substantially increases program risk by committing to an LRIP contract award with very limited information.

TEST AND EVALUATION SUMMARY

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF INITIALLY PROPOSED STREAMLINED DEVELOPMENT	OBSERVATIONS
Developmental Testing	Aggressive Schedule; Test Fleet Adequate	Test Fleet Inadequate; No Flexibility To Address Normal Developmental Issues	New Technologies Will Require Fine Tuning; RCS Testing Fly-Fix-Fly Process
MEP	Full AC Evaluation of MEP Before LRIP CA (Low-Mod)	Substantially Increases Risk	Full MEP 1 Year After LRIP CA, Not Evaluated in LUT
Reliability and Reliability Growth	Adequate Technical Feasibility Evaluation of Diagnostic and Reliability Criteria (Mod)	Increases Risk	Delayed Demonstrations and Evaluations of Critical Reliability Criteria, Reliability Growth at IOTE Estimated To Be 65-80%, Full Reliability IOC + 2 Years
OT&E Limited User Test	Adequate Flight/Simulator Hours to Verify Readiness for OT	Substantially Increases Risk	Flight Program Reduced, Not Adequate To Assess Readiness for OT
IOTE	IOTE Scheduled To Fly 750-1200 Hours With 8 AC	Increases Risk, Total Impact Not Clear	Revised Schedule Does Not Allow Evaluation of Block III Software

The panel considered the following elements in conducting its assessment of the test and evaluation impacts of "streamlining" COMANCHE development:

MEP

Full MEP is not evaluated in LUT, or before LRIP Contract Award.

SOFTWARE DEVELOPMENT

MEP Software for Block III is not evaluated during IOTE; no follow-on testing is scheduled to verify the production software.

DIAGNOSTIC SOFTWARE

Diagnostics software is delayed until completion of the Block III hardware upgrade, and will not reach maturity by IOTE.

PROTOTYPE MEP EVALUATION

Prototype MEP Evaluation will be accomplished using the second prototype aircraft, with a minimum 6-month delay to integrate full MEP in the first prototype. The first LRIP aircraft will not be available until the second quarter of FY 2003.

DIAGNOSTIC AND RELIABILITY FEASIBILITY

Diagnostic and Reliability Feasibility demonstrations are delayed, creating two major concerns: (1) It will be difficult to verify the two-level maintenance concept with an immature diagnostic capability, and (2) the Full Rate Production decision will occur before reliability growth achievement -- increasing the risk that the Government will commit to an immature design.

TEST AND EVALUATION

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF INITIALLY PROPOSED STREAMLINED DEVELOPMENT	OBSERVATIONS
DT&E:			
• MEP	Full AC Eval of MEP Before LRIP CA (Low-Mod)	Substantially Increases Risk	Dedicated MEP Platform Needed Full-MEP 1 Year After LRIP CA, Not Evaluated in LUT
- Software Development	Production Release at LRIP and Before IOTE (Mod-High)	Increased Risk	Production Release After IOTE, Functions of Incomplete Software More Critical Than the Percent Remaining
- Diagnostic Software	Developed and Tested During Hardware Reliability Testing (Mod)	Increased Risk	Diagnostic Software Delayed Until Completion of Hardware Development; Increased Risk to 2-Level Maintenance
- Prototype MEP Evaluation	AC With Full-MEP (Mod-High) 4-6 mo Delay To Upgrade Another Prototype	Increased Risk	1 AC With Full-MEP, Delay To Replace AC -2nd Qtr FY 03 With LRIP 2, 6 Mo For AV #1
- Diagnostic and Reliability Feasibility	Demonstrate Reliability and Diagnostic Thresholds (Mod-High)	Increased Risk	Phasing of Critical Reliability and Diagnostic Activities Is Unknown

PROTOTYPES

The program includes only two DEM/VAL prototypes rather than the three originally planned.

There is a 2 1/2-year delay between the delivery of the first and second prototypes.

There would be a 1 1/2-year gap in the flight test program for the first prototype; no flights are scheduled between late FY 1998 and the middle of FY 1999.

The limited number of test articles available to resolve developmental problems increases Program risk.

FLIGHT HOURS

User test flying hours were reduced from 324 hours to 24 prior to LRIP contract award.

RELIABILITY

Availability of only two prototypes adversely impacts reliability maturity.

RELIABILITY GROWTH

Reliability is estimated to be only 65-80 percent at IOTE; full reliability is not achieved until IOC + 2 years.

Entering full production before achieving required reliability increases the risk of committing to an immature design.

TEST AND EVALUATION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF INITIALLY PROPOSED STREAMLINED DEVELOPMENT	OBSERVATIONS
DT&E:			
• Prototypes	At Least 3 AC, Only 1 With Full-MEP (Mod-High) Second Full-MEP Aircraft Available in 4-6 Months	Substantially Increases Risk No Flexibility	1 AC MEP Evaluation, No Reaction to Down-Time or Crash Damage, Reliability Growth Delay
- Flight Hrs	Adequate Flight/Simulation Hours To Verify Thresholds and Gain Early Operational Insight (Low-Mod)	Increased Risk	Program Reduced to 24 Flight Hrs To Support LRIP CA, Significant Loss of Reliability Insight for 2-Level Maintenance
• Reliability	Adequate Technical Feasibility Evaluation of Diagnostic and Reliability Criteria (Mod)	Increased Risk	Delayed Demonstrations and Evaluations of Critical Reliability Criteria, Commitment for Baseline Reliability at IOC Not Clear
- Reliability Growth	Achieve at Least 60-70% of Maturity Threshold by LRIP CA (Low-Mod)	Increased Risk	Reliability Anticipated To Be 40-50% at LRIP, 65-80% by Full Production Decision - IOC+2 for Full Maturity

WEAPON EVALUATION

Limited gun firing before LRIP contract award will make it difficult to assess the effects of vibration loading on the MEP.

The schedule and phasing of rocket and missile firings is not defined.

Current attack helicopters have experienced problems with rocket gas ingestion. Rocket and missile locations on the COMANCHE are close to the engine air inlet area and thus may cause similar problems here.

BALLISTIC HARDNESS

The "streamlined" schedule does not define when the MS II decision will occur.

The MS II decision point must support the conduct of previously scheduled ballistics exit criteria, or there will be a significant increase in technical risk.

LIVE FIRE TEST & EVALUATION (LFT&E)

The "streamlined" program fails to clarify the plan to conduct a "full-up" test.

With only two prototypes and a limited number of LRIP aircraft available, a waiver from full-up LFT&E should be considered, if adequate ballistics and component LFT&E are accomplished.

RADAR CROSS SECTION (RCS) TESTING

Dynamic radar cross section testing on fixed wing aircraft has been flight test intensive involving a fly-fix-fly process to reduce and refine RCS signatures. Scheduled testing does not appear adequate to support a similar process on the COMANCHE.

TEST AND EVALUATION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF INITIALLY PROPOSED STREAMLINED DEVELOPMENT	OBSERVATIONS
DT&E:			
Weapon Evaluation	Gun Effect on MEP (Vibration Loads) & Engine Gas Ingestion Problems -- Rockets and Missiles (Low-Mod)	Increased Risk	Gun, Missile, Rocket Firings Before LRIP Contrct Award Not Defined
Ballistic Hardness	Coupon, Sub-Component Evaluation of Thresholds, Five Major Components Evaluated (Low-Mod)	Increased Risk	Ballistics Exit Criteria Not Achieved Before May 1995 OSD Review
Live Fire Test & Evaluation	Full-Up AC LFT&E Prior to Commitment to Full Production (Low-Mod)	Uncertain	"Demonstrations" Now Listed, Need Clarification of Streamlined LFT&E Plan, With Limited Resources Need To Request a Full-Up Waiver
RCS Testing	Aircraft Available to Dedicate to RCS Testing for Long Time Periods	Significantly Increased	Fixed Wing Dynamic RCS Testing Has Required Significantly More Time Than Planned. Fly-Fix-Fly Process. Questions Regarding Adequacy of Contractor Static RCS Facility

OT&E

Effectiveness

Only 24 flight hours are planned in LUT to assess readiness for IOTE.

Full MEP will not be evaluated in LUT.

The Block III production software will not be completed in time for IOTE.

Under the "streamlined" schedule, IOTE will be initiated with numerous uncertainties and unknowns, which is a higher risk strategy than the previous DEM/VAL approach.

Suitability

Reliability growth is expected to be 60 - 85 percent by IOTE.

Diagnostic capabilities will not be mature by IOTE.

Block III software will not be developed in time to be evaluated; no follow-on testing is scheduled to verify production software.

Evaluation of the two-level maintenance concept during IOTE will be limited by immature diagnostic capabilities and incomplete software development.

TEST AND EVALUATION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF INITIALLY PROPOSED STREAMLINED DEVELOPMENT	OBSERVATIONS
OT&E:			
Effectiveness	Adequate Flight/Simulator Hours in DT To Verify Readiness for OT (Low-Mod)	Substantially Increases Risk	DT Flight Hours Reduced, Not Adequate to Assess Readiness
	Robust Flight/Simulation DT&E Supports Early Operational Insight Prior to LRIP CA (Low-Mod)	Substantially Increases Risk	LUT Does Not Examine Full-MEP; EUT Eliminated; Flying Hours Reduced From 300+ Planned in OT and EUT to 24 During LUT
Suitability	IOTE Scheduled 750-1200 Hours of Flight Time Using 8 AC	Scheduled Number of AC Not Clear	IOTE Not Clarified
	Adequate Reliability Maturity & Diagnostic Capability Demonstrated in DT, Small Transition to OT Requirements (Low-Mod)	Increased Risk	Reliability Expected To Be 40-50% of APB at LRIP CA, Only 65-80% at IOTE and IOC, Estimate IOC+2 Before APB Requirements Met
	Maintenance Manning Level Well Developed During DT (Low-Mod)	Increased Risk	Diagnostics Capabilities Not Mature Enough to Verify 2-Level Maintenance Concept Before OT

In the panel's view, MANPRINT and training requirements should impose little or no risk as long as the requirements are identified in a timely manner and a sufficient number of training aircraft are made available.

MANPRINT/TRAINING SUMMARY

- OVERALL, MANPRINT AND TRAINING REQUIREMENTS SHOULD IMPOSE LITTLE OR NO RISK AS LONG AS THE REQUIREMENTS ARE IDENTIFIED AND SCHEDULE ADJUSTMENTS ARE MADE TO PROVIDE A SUFFICIENT NUMBER OF TRAINING AIRCRAFT

The following two charts report the panel's detailed assessment of MANPRINT and training risks. Under the existing contracted development, low or moderate risk is assigned to most aspects of MANPRINT and training. "Streamlining" the development should impose no additional risk.

MANPRINT/TRAINING

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Human Factors Engineering	Low	None	Soldier in the Loop Activities and Integration with Testing Are Being Maximized
System Safety	Low/Moderate	None	Moderate Rating Is Due to Current Head Borne Weight Helmet-Mounted Display System
Manpower	Low	None	The Manpower Estimate Report Has Already Been Approved by the US Army and DoD
Training	Moderate	None	The Current Program Does Not Provide Aircraft for the Time Frame That IKPT Is Scheduled and Thus Delays IOT
Integrated Training System	Low	None	Overall Rating of ITS Is Low Only When Delivery of Training Aircraft Is Excluded

MANPRINT/TRAINING (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Facilities	Low	None	Current Facilities at Ft. Rucker, AL, Ft. Eustis, VA, and Contractor Site Are Sufficient
Programs of Instruction	Low	None	The Contractor "Training Team" Is on Schedule and Should Continue To Remain as an Intregal Part of the Total RAH-66 Development Effort
Concurrency	Low	None	Well Established Plans Are in Place To Develop Training Systems and Coursework Along with Prototype A/C Development
System Diagnostics	Moderate	None	MEP Designs Are Not Fully Developed. Therefore the Related Diagnostic Systems Will Have To Be Designed and Tested During the DEM/VAL Phase
Embedded Training	Moderate	Positive Impact	ET Improvement Is Based on the US Army's Continual Updating of Training Requirements

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The achievement of a TWO-LEVEL MAINTENANCE concept is vital to the affordability of COMANCHE. This is the first Army program to eliminate "intermediate" level maintenance (and the costs associated with a third level of repair organizations). Repairs will either be performed at the front line by the operational unit level (by removal and replacement of line replaceable modules) or by the depot, where fault-isolated line replaceable modules will actually be repaired. The most critical elements of this approach are accurate fault detection and, especially, fault isolation. Improper removals of functioning modules will invalidate the two-level maintenance concept and significantly raise supportability costs. Two-level maintenance is crucial to the Army if they are to meet their Operations and Support cost goals and to realize a threefold increase in wartime flying hours with the same level of maintenance staff as on current programs.

The Streamlined Program reduces the risks in Depot Maintenance by maintaining contractor logistic support for several more years. The Army should solicit contractor logistic support, including supply management, for the entire life cycle of COMANCHE to further reduce risk and total program cost. Contractor logistics support reduces or eliminates the requirements for duplication of high cost test equipment at government depots and procurements of such items as technical data packages, technical manuals, and training equipment. Contractor supply support by commercial aircraft vendors has been demonstrated to be much more efficient than the classic military stockpiling concepts, also reducing program costs. These actions will also serve to keep work that is very similar to production skills and processes in place at the COMANCHE contractors. This will help maintain a "critical mass" of technologies, skills, processes, and the facilities and equipment for the future of the rotary wing industrial base.

SUPPORTABILITY SUMMARY

- TWO-LEVEL MAINTENANCE CONCEPT IS CRITICAL TO ACHIEVING PROGRAM COST GOALS
  - There Is No Army Precedent for This Concept
  - Requires That Diagnostic System Be Able To Accurately Detect and Isolate Faults to the Level of Line Replaceable Modules
  - Demonstration of Capability Should Not Be Delayed Until Full Mission Equipment Package Is Available

- THE ARMY SHOULD SOLICIT LIFE CYCLE CONTRACTOR LOGISTICS SUPPORT FOR COMANCHE TO REDUCE TOTAL PROGRAM COST
  - Eliminates Requirement To Procure Duplicate Equipment, Technical Data Packages, and Training
  - Use of Contractor Supply Support Should Also Reduce Total Program Cost
  - Will Help Maintain "Critical Mass" Within Helicopter Industrial Base

Additional details regarding the panel's assessment of supportability risk are shown here. The first and last items were covered in depth on the summary chart. As for the two remaining points, the following assessment is provided.

Reducing the number of prototypes in the "streamlined" program delays reliability maturity. The Acquisition Program Baseline Reliability Maturity goals are not expected to be achieved by the time of the full production decision without more prototype flying hours to validate reliability growth estimates.

Diagnostic Capability Demonstrations (especially fault isolation) need to be performed by Milestone II. Presently the development of diagnostic software is lagging the development of hardware and may be delayed until the completion of the full Mission Equipment Package. This further raises the question of fault isolation capability and the achievement of the two-level maintenance concept.

SUPPORTABILITY

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF STREAMLINED DEVELOPMENT	OBSERVATIONS
Achieving Two-Level Maintenance Concept	Moderate First Army Program To "Design-In" Only Organizational and Depot Level Maintenance (No Intermediate Level)	Moderate-High Delay in Full MEP Development Also Delays Diagnostic Software	Two-Level Maintenance Is Critical to: - Reducing O&S Costs - Sustaining 3X Wartime Flying Hours With Current Maintenance Manpower
Reliability Maturity	Low-Moderate	Moderate-High Reduction in Number of Prototypes Postpones Reliability Growth	Acquisition Program Baseline Will Not Be Achieved When Full Production Begins
Diagnostic Capability	Low-Moderate Demonstrations Before Milestone II	Moderate-High Phases of Demonstrations Unknown	Diagnostic Software Lags Hardware Development -- Questionable Fault Detection/Isolation Capability
Depot Maintenance Source of Repair	Transition from Contractor Support to Government Depot Imposes Low-Moderate Risk; But Is Very Costly in Duplication of Test Equipment, Technical Data, and Training	Low-Moderate Low if Contractor Logistics Support Is Sustained for the Life Cycle	Delays Transition from Contractor to Government Depot By Years

IV. CONCLUSIONS AND RECOMMENDATIONS

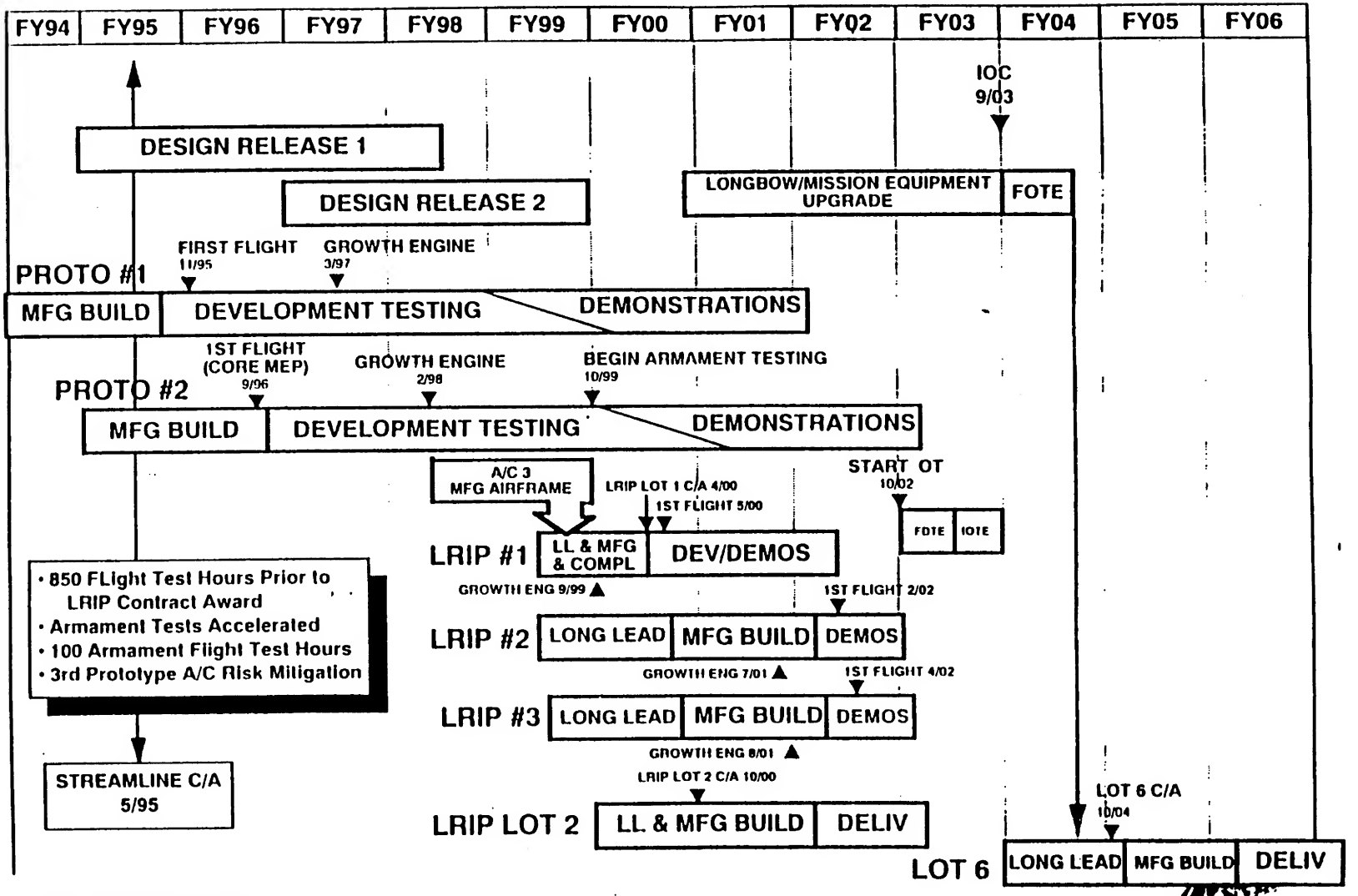
The final section of the briefing first reviews a revised "streamlined" development proposal offered by the COMANCHE Program Office on August 18, 1994 and then presents the conclusions and recommendations of the panel's assessment.

OUTLINE

- SCOPE AND APPROACH
- DEVELOPMENT ALTERNATIVES
- ASSESSMENT OF RISK IMPLICATIONS
- CONCLUSIONS AND RECOMMENDATIONS

Following the submission of its original "streamlined" proposal, the Army's COMANCHE Program Office significantly revised its approach, in large part to remedy deficiencies identified during the OSD review of the plan as well as objections raised in other critiques, including that of this panel. This chart shows the revised "streamlined" program as briefed to the review panel on August 18, 1994. Relative to the initial "streamlined" approach, the revised approach features a number of significant changes of which the principal alterations are summarized on the next two charts.

REVISED STREAMLINED PROGRAM



RAH-66 Comanche

This chart shows the COMANCHE Program Office's plan for developing the aircraft's mission equipment package. According to this plan, MEP development would be completed in four phases. The first MEP components, labeled the Core MEP, would be incorporated into the first two prototype aircraft. Design Release 1 would include the critical EOSS and the turreted gun system and would be available by mid FY 1998. Design Release 2 would include the balance of the COMANCHE's armament suite, the aircraft survivability equipment, comm systems, and the fault isolation system. This release would be available by the end of FY 1999. The final phase would include the LONGBOW target acquisition radar and some additional display, communications, and sensor modifications.

ARMY'S PROPOSED MEP DEVELOPMENT

CORE	DESIGN RELEASE 1	DESIGN RELEASE 2	LONGBOW/MEP UPGRADE
• Mission Computer • Flat Panel Displays • Data Buses, Aircraft Interface Units • Inertial Navigation Sensor • Global Positioning System • Automatic Flight Control Modes • Non-Development Items (VHF/UHF Radios, Transponder, Altimeter)	• Pilotage System • Targeting System • Helmet Mounted Display • Turreted Gun System • Doppler Navigation • Flight Director • Air Data System	• Armament System (HELLFIRE, Rockets, Fire Control) • Aircraft Survivability Equipment • Communications (HF Radio, ICNIA, COMSEC) • Mission Planning Station Interface • Plan-View Digital Map • Fault Isolation	• LONGBOW • Perspective Map • SATCOM • Integrated Fire and Flight Control • Image Intensification on the Nose

This chart compares a number of important aspects of the alternative development programs proposed for COMANCHE. The options compared include the existing contracted development program, the "streamlined" program initially proposed by the Army, the revised "streamlined" program briefed to the risk review panel on 18 August, and the option preferred by the risk review panel itself.

The specific program aspects used to compare the development alternatives are: (1) the level of OSD oversight, (2) the number of prototypes and their flight schedule, (3) the number of developmental flight test hours to be flown prior to the beginning of LRIP, (4) the proposed production schedule, and (5) the funding profile.

With regard to the level of OSD oversight, the panel believes that periodic high level OSD review imposes a degree of discipline that is generally beneficial. Although such reviews do have cost and schedule impacts, the panel would prefer that the Army look elsewhere for efficiencies.

With "streamlining," the number of prototypes to be built and tested has been reduced from the six planned under the existing development contract to five. Of these five, three would actually be low-rate initial production aircraft. Subsequent to testing, these aircraft would be refurbished and delivered to the Army as operational systems. The panel agrees that this approach offers efficiencies and better exploits the advantages of advanced design and manufacturing techniques than does the traditional DEM/VAL -EMD approach in which the EMD prototypes are tested and essentially discarded. The principal deficiency in the Army's proposed "streamlined" program's use of prototypes was the long delay between the first and second flight test aircraft. The Army's initial "streamlined" approach imposed a 2 1/2-year delay between the first flight of the first prototype and the first flight of the second. This interval has been reduced to roughly a year in the revised "streamlined" approach. The panel believes that program risk is generally lowered by the early availability of a number of prototypes and thus prefers the Army's revised approach to "streamlining."

Of equal importance with the number and delivery schedule of prototypes is the number of flight test hours planned. Under the Army's existing development contract, approximately 1,900 hours of flight tests were to have been conducted before LRIP contract award. Under the initial "streamlined" proposal, this number was reduced to 600 hours and more emphasis placed on simulation. The revised "streamlined" plan increases flight test hours prior to LRIP to 850. The panel believes that, in general, development risk is lowered as the number of flight test hours increases and

SUMMARY COMPARISON

PROGRAM ASPECT	EXISTING CONTRACTED DEVELOPMENT	ARMY'S INITIAL STREAMLINED PROPOSAL	ARMY'S REVISED STREAMLINED PROPOSAL	RISK REVIEW PANEL
OSD Oversight	MS II End FY 97 MS III FY 00	DAB Review May 95 Annual IPRs FY 97-00 MS III FY 04	DAB Review May 95 MS III FY 04	DAB Review May 95 MS II Early FY 99 MS III FY 04
Prototypes and Flight Schedule	3 DEM/VAL Late FY 95 - End FY 97 3 EMD FY 99- FY 02	1st DEM/VAL Early FY 96 2nd DEM/VAL Late FY 98 3 LRIP FY 01- FY 02	1st DEM/VAL Late FY 95 2nd DEM/VAL Late FY 96 3 LRIP FY 00 - FY 02	Risk Lowered by More Test Articles
Flight Test Hours Prior to LRIP	1900	600	850	Risk Lowered as Flight Test Hours Increase
Production Schedule	FY 01 24 FY 02 48 FY 03 96 FY 04 120	FY 00 8 FY 01 16 FY 04 24 FY 03 36	FY 00 3 FY 01 8 FY 02 12 FY 03 24	Risk Lowered as Early Production Schedule Slows
Funding Profile	Additional Funds Needed to Implement	Proposed to Fit Into Existing Profile	Proposed to Fit Into Existing Profile	Adjust As Needed to Ensure Timely Development

hence is concerned that the revised "streamlined" plan may still have reduced flight test hours too severely.

Under the Army's existing contract, production would have ramped up rapidly following the completion of the EMD phase, from 24 aircraft in FY 2001 to 120 aircraft in FY 2004. Although the planned production rate was slowed considerably under the "streamlined" plan, risk was actually increased in that the aircraft built in the first 4 or 5 production lots could require significant redesign depending on the outcomes of developmental and operational tests conducted with the first LRIP aircraft. The Army's revised "streamlined" plan slows the production rate further, and thus exposes fewer aircraft to redesign. Because some risk here seems unavoidable if any efficiencies are to be achieved in the development phase, the panel prefers the Army's revised "streamlined" approach to the one initially offered.

As for program funding, there seems to be universal agreement that additional resources would need to be added to the Army's proposed funding profile for COMANCHE in order to complete the DEM/VAL and EMD phases as originally planned. In fact, the severity of this fiscal constraint motivated the development of the "streamlined" approach. According to the COMANCHE Program Office, both the initially proposed "streamlined" approach and the revised approach could be accomplished within the currently proposed funding profile. The panel would prefer that a detailed assessment be made of funding needs and that appropriate adjustments, including funding increases where necessary, be made in order to ensure timely development of the air vehicle, mission equipment, and armament.

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The conclusions drawn from the panel's assessment are summarized on this chart and the one following.

The COMANCHE helicopter is a complex aircraft that incorporates a substantial number of technological advances. COMANCHE features an all-composite fuselage, new main and tail rotor designs (specifically a bearingless main rotor and a fan-in-fin tail rotor), and digital (or fly-by-wire) flight controls. The design also incorporates significant signature reduction to reduce its detectability by radar, infrared, and acoustic sensors. COMANCHE will be equipped with an integrated avionics suite comparable to those found on advanced fixed-wing aircraft and thus involves a substantial amount of on-board and support software, 90 percent of which is to be written in Ada. The helicopter's sensor suite includes advanced night vision pilotage and target acquisition systems built around focal plane array FLIRs. To improve supportability, COMANCHE will have a built-in fault detection system.

Boeing and Sikorsky have devised an impressive approach for developing and manufacturing the COMANCHE. The team is using sophisticated computer-aided design/computer-aided manufacturing (CAD/CAM) technology built around the CATIA computer code. This approach has enabled the contractors to achieve very close tolerances (roughly 40 times more precise than those obtained previously) in the assembly of the composite materials used in the aircraft's fuselage. The contractors have also implemented integrated process development teams to ensure that all essential considerations are taken into account early in the design. Thus, teams of designers, manufacturers, users, and maintainers are able to identify and solve problems early in the development rather than having to make changes after the system has already been built.

The COMANCHE program is underfunded. The persistent budgetary constraints imposed on the Department of Defense have made it difficult for the Army to allocate sufficient resources to fund COMANCHE development. The Army's proposed "streamlined" approach was advanced primarily as a means of fitting the program within the available funding profile. The panel's assessment is that this level of resources falls somewhat short of the dollars that will be needed.

CONCLUSIONS

- COMANCHE IS COMPLEX SYSTEM WITH SUBSTANTIAL NUMBER OF TECHNOLOGICAL ADVANCES
  - All Composite Fuselage
  - New Rotor Designs: BMR/Fan-In-Fin
  - Signature Reduction: Radar, IR, Acoustic
  - Integrated Avionics with Substantial ADA Software
  - NVPS & TAS Using Focal Plane Array FLIR
  - Built-In Fault Detection

- BOEING-SIKORSKY HAVE IMPRESSIVE APPROACH
  - Sophisticated CAD/CAM Process -- Very Close Tolerances Achieved
  - Integrated Process Teams To Identify and Solve Problems Early
  - Extensive Simulation and Laboratory Facilities To Facilitate Design

- COMANCHE PROGRAM IS UNDERFUNDED
  - Army's Streamlined Approach Proposed As Means To Fit Program Within Resources
  - However, Proposed Resources Will Not Support Realistic Development

For the most part, the Army's proposed "streamlining" approach does not increase the piecewise risk of separate subsystem or process developments associated with the COMANCHE. The panel found that these risks vary from low to high, depending on the specific subsystem or process being considered. Overall, most of the risks fell in the low to moderate range. Only a few subsystems or processes were found to be high risk.

The most significant development risks are those associated with integration of the separate subsystems into the total aircraft system and the operation of that total system. In the panel's view, the "streamlined" development approach initially proposed by the Army would increase the overall program risk by reducing the number of test aircraft and the number of planned flight hours. Further risks were imposed by stretching the delivery of prototypes to the point that only a single test aircraft was available for the first 2 1/2 years of flight testing.

The revised "streamlined" approach briefed to the panel on 18 August mitigates some of these risks by significantly increasing the number of planned flight test hours and shortening the time between delivery of prototype aircraft. However, in the panel's view the revised plan still imposes significant overall risk by failing to schedule sufficient OSD oversight to ensure that the development continues to meet Defense Department needs. According to the revised program, a Milestone II review would be held in May 1995 and then no comparable level oversight would be scheduled until a Milestone III review in FY 2004. Although In-Process reviews would be held periodically, the panel did not view these as enabling the same level of oversight as the traditional major milestone reviews.

In short, the panel concluded that while considerable efficiencies might be attained through some aspects of streamlining, the Department would do well to avoid shortcutting the development process too severely. The panel supports the COMANCHE program office's plan to smooth the transition from DEM/VAL to EMD so as to exploit fully the benefits of the advanced CAD/CAM design techniques being used. Likewise, the panel supports the Army's proposal to obtain relief from particularly burdensome, but generally ineffectual, regulatory requirements. However, the panel does not support the overly severe cuts made in the resources allocated to system integration and flight test.

CONCLUSIONS (Cont'd)

- FOR THE MOST PART, PROPOSED STREAMLINING APPROACH DOES NOT INCREASE PIECEWISE RISK OF SEPARATE SUBSYSTEM OR PROCESS DEVELOPMENTS
  - Risks Vary From Low to High Depending on Specific Subsystem or Process, With Most Falling in Low to Moderate Range

- MOST SIGNIFICANT DEVELOPMENT RISKS ARE IN INTEGRATION AND TOTAL SYSTEM OPERATION
  - Initially Proposed Streamlined Approach Increased These Risks By Reducing Test Aircraft and Stretching Schedule

  - Revised Streamlined Approach Mitigates Some Risks But Still Imposes Significant Overall Risk By Placing Milestone II in May 1995 and Milestone III in FY 2004

  - Cannot Shortcut Development Process Needed To Ensure That Entire System Works As Desired

Based on its assessment, the panel offers the following recommendations:

To ensure appropriate OSD oversight for COMANCHE development, the Army should retain a conventional standard event-driven schedule. In particular, a milestone review with clearly defined exit criteria should be held just prior to the LRIP long lead award. A review at this point would follow the initial flight tests of the first two prototype aircraft equipped with the core MEP and the initial demonstration of MEP Design Release 1, which includes the key night pilotage and target acquisition system components of the EOSS.

At the LRIP milestone review, the Department should reexamine overall COMANCHE program requirements to ascertain that the system remains essential in the face of the changing strategic environment. In particular, the Army should update the COMANCHE cost and operational effectiveness analysis (COEA) based on current DoD planning scenarios and, to the extent possible, demonstrated system performance. The review should also determine if the COMANCHE would provide a suitable means for satisfying any Marine Corps or Special Operations Force (SOF) requirements for an aircraft of this type.

OSD and the Army should adjust the funding profile for the COMANCHE program, and where necessary provide additional funding, in order to ensure timely development of the air vehicle, mission equipment, and armament.

The COMANCHE Program Office should seek regulatory relief from those regulations and policies that impose a financial burden out of proportion to the benefits released. While most of these regulations fall within the purview of OSD or the Department of the Army, in a few instances Congressional approval will be required. For specific guidance in this area, the panel defers to the detailed regulatory review conducted by Burdeshaw Associates for the COMANCHE Program Office.

RECOMMENDATIONS

- RETAIN EVENT-DRIVEN SCHEDULE, IN PARTICULAR A MILESTONE REVIEW WITH CLEARLY DEFINED EXIT CRITERIA TO BE HELD JUST PRIOR TO LRIP LONG LEAD AWARD
  - Flight Test Results From First Two Prototype Aircraft and Core MEP
  - Initial Demonstration of MEP Design Release 1 (EOSS)

- REEXAMINE PROGRAM REQUIREMENTS AT LRIP MILESTONE REVIEW
  - Update COEA Based on Current Planning Scenarios and Demonstrated System Performance
  - Include Potential USMC and SOF Requirements, If Any

- INCREASE OVERALL FUNDING AND ADJUST FUNDING PROFILE TO EXECUTE PROGRAM AS OUTLINED ABOVE AND ENSURE TIMELY DEVELOPMENT
  - Air Vehicle
  - Mission Equipment
  - Armament

- SEEK REGULATORY RELIEF PER BURDESHAW STUDY RECOMMENDATIONS
  - Virtually All Issues Within OSD or Army Purview

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APPENDIX A
ACRONYMS AND ABBREVIATIONS

APPENDIX A
ACRONYMS AND ABBREVIATIONS

AC	aircraft
APB	acquisition planning baseline
ASE	aircraft survivability equipment
ASIC	application specific integrated circuit
AV	air vehicle
BeAl	beryllium aluminum (alloy)
BMR	bearingless main rotor
C&D	controls and displays
CA	contract award
CAD	computer-aided design
CAM	computer-aided manufacturing
CDR	critical design review
COEA	cost and operational effectiveness analysis
COMSEC	communications security
CSC	Conventional Systems Committee
DAB	Defense Acquisition Board
DEL	delivery
DELIV	delivery
DEM/VAL	demonstration/validation
DEMOS	demonstrations
DEV	development
DT	developmental testing
DTC	design to cost
DT&E	developmental test and evaluation
EMD	engineering and manufacturing development
EO	electro-optical
EOSS	electro-optical sensor suite
ET	embedded training
EUT	early user test
FCR	fire control radar
FDTE	final development test and evaluation
FLIR	forward-looking infrared
FLT	flight
FOTE	final operational test and evaluation
FPA	focal plane array
FY	fiscal year
GFE	Government furnished equipment
HF	high frequency (communications)

I2TV	image intensifying television
IC	integrated circuit
ICNIA	integrated communications, navigation, identification
ID	identification
IKPT	Initial Key Personnel Training
IOC	initial operational capability
IOT	initial operational test
IOTE	Initial Operational Test and Evaluation
IPR	in-process review
IR	infrared
ITS	integrated training system
KSLOC	thousands of source lines of code
LFT&E	live fire test and evaluation
LL	long lead (production)
LRIP	low-rate initial production
LUT	limited user test
MANPRINT	
MEP	mission equipment package
MFG	manufacturing
Mil Spec	military specifications
mm	millimeter
MS	milestone
ms	millisecond
NBC	nuclear, biological, chemical
NVPS	night vision pilotage system
O&S	operating and support (costs)
OSD	Office of the Secretary of Defense
OT	operational test
OT&E	operational test and evaluation
PROC	procurement
PROD	production
PROTO	prototype
PRR	production readiness review
RCS	radar cross section
RDTE	research, development, test and evaluation
RF/D	range finder/designator (laser)
SATCOM	satellite communications
SEM-E	standard electronic module
SLOC	source lines of code
SOF	Special Operations Forces
STEP	Software Test and Evaluation Panel
TAS	target acquisition system
UHF	ultra high frequency (communications)
USMC	U.S. Marine Corps
VHF	very high frequency (communications)

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APPENDIX B
TEST AND EVALUATION RISKS OF REVISED STREAMLINED DEVELOPMENT

This appendix presents the Review Panel's assessment of the test and evaluation risks associated with the COMANCHE Program Office's revised "streamlined" development approach which was briefed to the panel on August 18, 1994. The format is the same as that used in our assessment of the test and evaluation risks associated with the Army's original "streamlined" development proposal.

MEP

The revised "streamlined" approach has four MEP developments: the core system, Design Releases 1 and 2, and the LONGBOW-MEP upgrade. Design Releases 1 and 2 will be evaluated during LUT. The user position on this approach is not known. Several of the LONGBOW-MEP upgrade components were a part of the former Full MEP. The MEP Upgrade will be evaluated in an FOTE scheduled for early in FY 2004.

The Army's revised MEP development approach is, in effect, four developments. While some test redundancy will occur, there may actually be a reduction in MEP development risk, as the development is spread over a longer period.

RELIABILITY AND RELIABILITY GROWTH

Expected reliability growth at LUT is 45-55 percent, and only 65-80 percent at IOTE. Full reliability growth is not expected to be achieved until IOC + 2 years. The revised schedule initiates the second prototype development much earlier and provides 100 more flight hours before LUT. However, there is a 1 1/2-year break in the first prototype flight schedule (Dec. 1997 - Aug. 1999), and the second prototype has a 9 month break in its flight schedule (Jul. 1997 - Mar. 1998). These breaks significantly delay reliability growth.

Demonstration and evaluation of critical reliability criteria are still delayed, primarily due to flight schedule breaks. Commitment to Full Rate Production before achievement of reliability growth requirement increases the risk of producing an immature design.

Diagnostics maturity is critical to an accurate assessment of two-level maintenance. The delay in software development will impact proper maturity of the diagnostics capabilities that are essential for proper fault detection and resolution of the supportability concept.

TEST AND EVALUATION SUMMARY

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF REVISED STREAMLINED DEVELOPMENT	OBSERVATIONS
Developmental Testing	Aggressive Schedule, Test Flight Adequate	Increases Risk, Limited Flexibility To Address Normal Developmental Issues	
MEP	Full AC Evaluation of MEP Before LRIP CA (Low-Mod)	Substantially Increases Risk	Full MEP (Design Releases 1 & 2) Integrated and Tested in LUT
Reliability and Reliability Growth	Adequate Technical Feasibility Evaluation of Diagnostic and Reliability Criteria (Mod)	Increases Risk	Demonstrations and Evaluations of Critical Reliability Criteria, Reliability Growth Achieved at IOTE Not Defined, Appears Reliability Requires IOC + 2 Years
OT&E Limited User Test	Adequate Flight/Simulator Hours To Verify Readiness for OT	Substantially Increases Risk	Flight Program Reduced, Not Adequate to Assess Readiness for OT
IOTE	OT Scheduled To Fly 750-1200 Hours With 8 AC (Low-Mod)	Increases Risk	Mission Equipment Upgrade Not Tested in IOTE

OTE

This program revision does not restore the flight hours reduced by the initial streamlining that eliminated EUT (a test consisting of 3 aircraft and 300 flying hours).

The revised "streamlined" program still proposes 24 flight hours for LUT, does not evaluate Full MEP as it was formerly defined (the MEP upgrade now contains components that were once a part of the "Full MEP"), and will not evaluate the final production software until FOTE.

The proposed flying hour program is marginal to assess readiness for IOTE, and increases program risk by committing to an LRIP contract award with limited information.

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MEP

MEP Design Releases 1 and 2 are evaluated in LUT. The LONGBOW-MEP upgrade is not tested during IOTE.

SOFTWARE DEVELOPMENT

Software for the MEP upgrade is evaluated during FOTE.

DIAGNOSTIC SOFTWARE

Complete Diagnostics software development will be delayed until completion of the MEP upgrade, and will not reach maturity by IOTE.

Prototype MEP Evaluation will be accomplished using the second prototype aircraft. A 4-6 month delay will be incurred to integrate the full MEP in the first prototype.

DIAGNOSTIC AND RELIABILITY FEASIBILITY

Diagnostic and Reliability Feasibility demonstrations are delayed, creating two concerns: (1) the Program's ability to verify the two-level maintenance concept with an immature diagnostic capability, and (2) the Full Rate Production decision is scheduled before reliability growth is achieved raising the risk of committing to an immature design.

TEST AND EVALUATION

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF REVISED STREAMLINED DEVELOPMENT	OBSERVATIONS
DT&E: • MEP	Full AC Eval of MEP Before LRIP CA (Low-Mod)	Increased Risk	Full-MEP (Design Releases 1 & 2) Tested in LUT, Production Upgrade Not Tested in IOTE
- Software Development	Production Release at LRIP and Before IOTE (Mod-High)	Increased Risk	Production Release for MEP Designs I & II Before IOTE, Production Upgrade Software Not Verified in IOTE, Functions of Incomplete Software More Critical Than the Percent Remaining
- Diagnostic Software	Developed and Tested During Hardware Reliability Testing (Mod)	Increased Risk	Diagnostic Software Delayed Until Completion of Hardware Development Increased Risk to 2-Level Maintenance
- Diagnostic and Reliability Feasibility	Demonstrate Reliability and Diagnostic Thresholds (Mod-High)	Increased Risk	Phasing of Critical Reliability and Diagnostic Activities Is Not Defined

PROTOTYPES

The program still contains only two DEM/VAL prototypes.

The development delay between flights of the first and second prototypes is reduced from 2 1/2 years to 1 year.

The flight test schedule for the first prototype has a 1 1/2-year break; the schedule for the second prototype now has a 9 month break.

FLIGHT HOURS

The Army's initial "streamlining" approach reduced the flying hours supporting LRIP contract award from 324 hours to 24 hours. The revised program still proposes a 24 hour program for LUT; EUT is not restored.

RELIABILITY

The availability of only two DEM/VAL prototypes adversely impacts reliability maturity.

RELIABILITY GROWTH

Reliability is estimated to be only 65-80 percent at IOTE; achievement of full reliability is not expected until 2 years after IOC.

Flight schedule breaks delay reliability growth.

Entering full production before achieving required reliability may lead to the Government's committing to an immature design.

RADAR CROSS SECTION (RCS) TESTING

Scheduled flight hours are marginal to support RCS testing beyond baseline system characterization.

TEST AND EVALUATION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF REVISED STREAMLINED DEVELOPMENT	OBSERVATIONS
DT&E:			
• Prototypes	3 AC, Only 1 With Full-MEP (Mod-High) Second Full-MEP AC Available in 4-6 Months	Increased Risk	1 AC MEP Evaluation Results in a Reliability Growth Delay
- Flight Hrs	Adequate Flight/Simulation Hours To Verify Thresholds and Gain Early Operational Insight (Low-Mod)	Increased Risk	Program Reduced to 24 Flight Hrs to Support LRIP LL and LRIP CA, Significant Loss of Reliability Insight for 2-Level Maintenance
• Reliability	Adequate Technical Feasibility Evaluation of Diagnostic and Reliability Criteria (Mod)	Increased Risk	Demonstration Schedule and Evaluations of Critical Reliability Criteria, Commitment for Baseline Reliability at IOC Not Clear
- Reliability Growth	Achieve at Least 60-70% of Maturity Threshold by LRIP CA, 80-90% by IOTE (Low-Mod)	Increased Risk	Previous Reliability Estimates Were: 40-50% at LRIP, 65-80% by Full Production Decision - IOC+2 for Full Maturity, Current Reliability Growth Unclear

WEAPON EVALUATION

The schedule for gun firings before LRIP contract award is uncertain, thus raising concern about the program's ability to conduct timely assessments of the vibration loading effects on the MEP.

The schedule and phasing of rocket and missile firings is uncertain.

Current attack helicopters have experienced problems with rocket gas ingestion. Rocket and missile locations on COMANCHE are close to the engine air inlet area.

BALLISTIC HARDNESS

The revised "streamlining" schedule does not specify when the MS II decision will occur. A May 1995 review is incompatible with the previously planned ballistics exit criteria.

Committing to EMD without adequate ballistics testing increases risk. Several of the components are made of composite materials that have not been adequately tested.

LIVE FIRE TEST & EVALUATION

The revised "streamlined" program does not identify when a "full-up" test would be conducted.

With only two DEM/VAL prototypes and a limited number of LRIP aircraft available, a waiver from full-up LFT&E should be considered, provided that adequate ballistics and components LFT&E is accomplished.

TEST AND EVALUATION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF REVISED STREAMLINED DEVELOPMENT	OBSERVATIONS
DT&E:			
Weapon Evaluation	Gun Effect on MEP (Vibration Loads), & Engine Gas Ingestion Problems -- Rockets and Missiles (Low-Mod)	Increased Risk	Availability of Gun, Missile, Rocket Firing Data Before LRIP CA is Not Clear
Ballistic Hardness	Coupon, Sub-Component Evaluation of Thresholds and Five Major Components Evaluated (Low-Mod)	Increased Risk	Tests Are Scheduled Well After Army's Proposed MS II (May 95)
Live Fire Test & Evaluation	Full-Up AC Evaluation Prior to Commitment to IOTE (Low-Mod)	Uncertain	Need Clarification of Streamlined LFT&E Plan, Waiver for "Full-Up" LFTE To Be Requested
RCS Testing	Aircraft Available to Dedicate to RCS Testing	Increased Risk	Fixed Wing Dynamic RCS Testing Has Required Significantly More Time Than Planned. Fly-Fix-Fly Process. Questions Regarding Adequacy of Contractor Static RCS Facility

EFFECTIVENESS

Only 24 flight hours are included in LUT to assess readiness for IOTE.

Only MEP Design Releases 1 and 2 will be evaluated in LUT.

IOTE will not be able to evaluate the production software.

The revised "streamlined" schedule could result in entering IOTE with problems not identified during development.

SUITABILITY

Reliability growth is expected to be 60-85 percent by IOTE.

Full diagnostic capabilities will not be mature by IOTE.

MEP Upgrade software will not be developed in time to be evaluated in IOTE. FOTE will be used to verify production software.

Evaluation of the two-level maintenance concept during IOTE will be limited by immature diagnostic capabilities and lagging software development.

TEST AND EVALUATION (Cont'd)

ELEMENT	RISK ASSUMING EXISTING CONTRACTED DEVELOPMENT	EFFECT OF REVISED STREAMLINED DEVELOPMENT	OBSERVATIONS
<u>OT&E:</u>			
Effectiveness	Adequate Flight/Simulator Hours in DT To Verify Readiness for OT (Low-Mod)	Substantially Increases Risk	DT Flight Hours Reduced, Not Adequate to Assess Readiness
	Robust Flight/Simulation DT&E Supports Early Operational Insight Prior to LRIP CA (Low-Mod)	Substantially Increases Risk	LUT Examines MEP Design Releases 1 & 2, Flying Hours Reduced to 24 During LUT
Suitability	IOTE Scheduled 750-1200 Hours of Flight Time Using 8 Aircraft	Increases Risk	IOTE Will Not Evaluate Production Upgrade Software
	Adequate Reliability Maturity & Diagnostic Capability Demonstrated in DT, Small Transition to OT Requirements (Low-Mod)	Increases Risk	Previous Streamlined Estimates Were 40-50% of APB at LRIP CA, Only 65-80% at IOTE and IOC, Estimate IOC+2 Before APB Requirements Met, New Streamline Reliability Growth Is Unclear
	Maintenance Manning Level Well Developed During DT (Low-Mod)	Increases Risk	Diagnostics Capabilities May Not Be Mature Enough To Verify 2-Level Maintenance Concept Before OT

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13. ABSTRACT *(Maximum 200 words)*

This paper reports the results on an independent assessment of the risks associated with the Army's proposed plan to streamline development of the new RAH-66 COMANCHE armed reconnaissance helicopter. The assessment was conducted by a panel of outside experts assisted by senior research staff from the Institute for Defense Analyses. The panel first identified the risks associated with the existing development approach and then determined the incremental risk, if any, imposed by the Army's proposed streamlined development. The specific areas in which risks were investigated included airframe and propulsion, mission equipment and armament, software, producibility, training, test and evaluation, and supportability. Based on its assessment, the panel recommended a number of changes in the Army's development approach.

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